SALT LAKE CITY CORPORATION

THE DEPARTMENT OF PUBLIC UTILITIES

PROJECT MANUAL FOR CONSTRUCTION OF

City Creek Treatment Plant Upgrades - CM/GC

PROJECT NO. 512260095

FISCAL YEAR 2024/2025

WORK PACKAGES

BRIC Package – Project No. 512260079

90% GMP ISSUE

ERIN MENDENHALL
Mayor

City Council

VICTORIA PETRO
ALEJANDRO PUY
CHRIS WHARTON
EVA LOPEZ CHAVEZ
DARIN MANO
DAN DUGAN
SARAH YOUNG

ENGINEERING DIVISION
1805 W. 500 S.
SALT LAKE CITY, UTAH 84104

LAURA BRIEFER
Director

JESSE STEWART
Deputy Director

JASON BROWN, P.E.
Deputy Director

JASON DRAPER, P.E.
Chief Engineer

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SALT LAKE CITY CORPORATION
Salt Lake City, Utah

PROJECT MANUAL

FOR

City Creek Treatment Plant Upgrades - CM/GC

PROJECT NO. 512260095

WORK PACKAGES

BRIC Package– Project No. 512260079

PREPARED FOR

DEPARTMENT OF PUBLIC UTILITIES
ENGINEERING DIVISION
1805 W. 500 S.
SALT LAKE CITY, UTAH 84104

PREPARED BY

Brown and Caldwell
6975 Union Park Center
Suite 490
Midvale, Utah 84047

Project Manager: Jared Carr, P.E. (JACOBS on behalf of DPU)
Brown and Caldwell Project Manager: Steven Brenchley, P.E.

2024

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T A B L E O F C O N T E N T S

CITY CREEK TREATMENT PLANT UPGRADES

BRIC PACKAGE

WP1 – GENERAL CONDITIONS & SITE SERVICES

90% Design

Project No. 512260079

DIVISIONS

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46 WATER AND WASTEWATER EQUIPMENT

END OF DOCUMENT

SECTION 01 11 00

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. The work covered under this contract will be performed at Salt Lake City Department of Public Utilities' (SLCDPU) City Creek Water Treatment Plant located at 2200 City Creek Canyon Road, Salt Lake City UT, 84103

1.02 DESCRIPTION OF OWNER'S PROJECT

A. The overall project shall consist of furnishing tools, equipment, materials, supplies, and furnishing all labor, transportation, and services, including fuel, power, water, and essential communications, and performing all work or other operations required for the fulfillment of the Contract in strict accordance with the Contract Documents. The Work shall be complete and all work, materials, and services not expressly indicated or called out in the Contract Documents which may be necessary for the complete and proper construction or the Work in good faith shall be provided at no increase in cost to the Owner.

1.03 WORK OF THIS CONTRACT

A. The work to be performed under this contract includes furnishing of all labor, materials and services required for the City Creek Treatment Plant BRIC Package project. Specific features include, but are not limited to:
   1. Construction of a new conventional water treatment plant within the footprint of the existing flocculation and sedimentation basins.
   2. Construction of all yard piping associated with the new treatment plant to make it operational.
   3. Construction of an addition to the existing Fluoride Building.
   4. Construction of a septic drain tank, discharge pipe, and drain field.
   5. Modifications to the existing clarifier to include replacement of the rake arm/motor, replacement of reclaim pumps, placement of a geodesic dome cover, construction of a vestibule over the control cabinet, construction of new stair access to clarifer.
   6. Construction a soil nail/shotcreet retaining wall on the south side of the clarifier.
   7. Construction of piping and gates between Drying Beds 1 and 2 and Beds 2 and 3.
   8. Construction of infiltration gallery.
   9. Modifications to the existing Operations Building to house a new 1,000kW generator, demolition of the existing 1,000 gallon external fuel tank, and construction of a new 3,000 gallon external fuel tank.
   10. Construction of rock weirs in the City Creek channel between the intake and footbridge.
   11. Raising the creek channel embankment adjacent to the Fluoride Building.
   12. Demolition of the existing Filter Building.
   13. Demolition of the plant inlet channel from the operations building to the flocculation basin distribution channels.

B. Except as specifically noted otherwise, provide and pay for:
   1. Insurance and bonds.
   2. Labor, materials, and equipment.
   3. Applicable sales tax.
   4. Tools, equipment and machinery required for the Work.
   5. Traffic control and dust control measures.
   6. Other facilities and services necessary for proper execution and completion of Work.
   7. Permits for disposal of demolished construction materials, if required; provide a chain-of-custody document to OWNER upon completion of the Work to document proper disposal.

C. Work shall be performed while minimizing shutdowns and interference to the existing water treatment plant operations.

D. Work shall be performed while minimizing interference to the existing public walking and bike paths of City Creek Canyon
   1. Contractor shall schedule the Work with Owner to minimize interference.

1.04 ACTIVITIES BY OTHERS

A. Owner, utilities, and others may perform activities within Project area while the Work is in progress.

B. Activities by others which may affect performance of work include:
   1. Water treatment plant operations
   2. Chemical deliveries
   3. Routine maintenance
   4. Public recreation on the main road of City Creek Canyon on weekends and Holidays between the canyon entrance gate and Picnic Site 16.

C. Cooperate with others to minimize interference and delays.

1.05 EARLY OCCUPANCY OF PORTIONS OF WORK

A. Substantially Complete following portions of Work for Owner's early occupancy including specified testing, training of Owner's personnel, and other preparations necessary for Owner's occupancy or use:
   1. New Treatment Building Facility (flash mix, flocculation, sedimentation, filtration, chlorine contact gallery, and backwash pumping facilities).

B. Certificates of Substantial Completion will be executed for each designated portion of Work prior to Owner occupancy.

C. Following occupancy, Owner will:
   1. Provide power to operate equipment and systems.
   2. Repair damage caused by Owner's occupancy.

1.06 COMPIANCE WITH DRINKING WATER PERMIT

A. The existing facility operates under the terms of a permit issued by the Utah Division of Drinking Water. This permit specifies the water quality limits that the plant must meet prior to discharge of finished water.

B. Contractor shall bear the costs of penalties imposed on the Owner for water quality violations caused by actions of the Contractor, including any and all costs to remedy the situation.

END OF SECTION

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SECTION 01 11 80
ENVIRONMENTAL CONDITIONS

PART 1 GENERAL

1.1 ENVIRONMENTAL CONDITIONS

A. This section describes the environmental conditions which have been observed at the site of the work and which may reasonably be anticipated throughout the life of the project.

1.2 CLIMATE CONDITIONS

A. The work elevation is approximately 5,335 feet above mean sea level. In the winter, snow may be present earlier and last longer than at lower elevations.

B. Climate conditions are described as follows:

Description	Range of Conditions
Low Winter Temperature (degrees F)	10° (average), -12° (low)
High Summer Temperature (degrees F)	84° (average), 97° (high)

1.3 ADDITIONAL CONDITIONS

A. Additional conditions which may be applicable are specified in other sections.

END OF SECTION

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SECTION 01 12 16

WORK SEQUENCE AND RESTRICTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for sequencing and scheduling the Work affected by existing site and facility, work restrictions, and coordination between construction operations and plant operations.

B. Related Sections:
   1. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01 11 00 – Summary of Work
      b. Section 01 32 17 – Baseline and Progress Schedules
      c. Section 01 33 00 – Submittal Procedures
      d. Section 33 01 30 – Bypass Piping and Pumping

1.02 DEFINITIONS

A. Reduced Capacity Shutdown: A reduced capacity shutdown occurs when the plant is able to produce a reduced quantity of finished water that meets the drinking water permit requirements.

B. Full Plant Shutdown: A full plant shutdown occurs when the plant is not able to produce any finished water that meets the drinking water permit requirements.

C. Substantial Completion: As defined in Section 00 72 00 Part 14.5.

1.03 SUBMITTALS

A. CONTRACTOR to submit detailed schedule describing work tasks, crew, schedule, materials, and equipment needed during shutdown period for approval to ENGINEER at least one (1) month prior to shutdown event (refer to forms immediately following this specification)

B. WORK SEQUENCE PLANS, Submit Work Sequence Plans detailing the contractors activities are scheduled and coordinated between the various work activities and contract requirements. Failure to coordinate the various requirements causing rework and additional work is contractors responsibility.

1.04 PART 2 GENERAL CONSTRAINTS ON SEQUENCE AND SCHEDULING OF WORK

A. Water projects:
   1. Conduct Work such that the Owner's ability to meet its customer's demands for treated drinking water shall not be impaired or reduced in terms of the required quantity or quality of treated water. Do not impair the operational capabilities of essential elements of the treatment process or reduce treatment capacity below levels sufficient to meet demands for water throughout the contract time. The quantities of and quality of treated water required are described in this Section.
   2. The existing facility operates under the terms of a permit issued by the Utah Division of Drinking Water. This permit specifies the water quality limits that the plant must meet prior to discharge of finished water. A copy of the existing permit is on file for review at the Utah Division of Drinking Water. Contractor shall bear the cost of penalties imposed on the Owner for water quality violations caused by actions of the Contractor, including any and all costs to remedy the situation.
   3. The Owner will obtain project approval from the Utah Division of Drinking Water prior to the contractor beginning construction onsite.

B. Work sequence and constraints presented do not include all items affecting completion of the Work, but are intended to describe critical events necessary to minimize disruption of the existing facilities and to ensure compliance with Utah Pollutant Discharge Elimination System (UPDES) and other permit requirements.

C. The work sequencing and description of critical events provided in this Section are provided to assist the Contractor in scheduling and undertaking the Work. They do not include all items affecting completion of the Work but are intended to describe critical events necessary to minimize disruption of the existing facilities and to ensure compliance with water quality permit requirements, and Owner’s water quality standards.

D. The constraints provided in this Section are contractual obligations that limit the Contractor’s activities and the Contractor’s impact to plant operations.

E. General plant shutdown constraints:
   1. Activities that disrupt individual process operations must comply with these shutdown constraints.
   2. Provide thorough advanced planning, including having required equipment, materials, and labor on hand at time of shutdown.
   3. Where required to minimize treatment process interruptions while complying with specified sequencing constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.
   4. Final determination of the permitting of shutdowns will be the sole judgment of the Owner. Any full treatment plant shutdown, or significant reduction in treatment capacity or treatment capabilities, must be authorized by the SLC Department of Public Utilities Director or Deputy Director.
   5. Owner maintains the ability to abort shutdown on the day of the scheduled shutdown.
   6. During shutdown period, Contractor shall work longer workdays and on weekends to minimize shutdown period. Contractor shall use additional work crews as needed to meet shutdown restrictions including schedule constraints.

7. Contractor to submit detailed schedule describing work tasks, crew, schedule, materials, and equipment needed during shutdown period for approval to Engineer at least one (1) month prior to shutdown event (refer to forms immediately following this specification).

F. Definitions
   1. Reduced Capacity Shutdown: A reduced capacity shutdown occurs when the plant is able to produce a reduced quantity of finished water that meets the drinking water permit requirements.
   2. Full Plant Shutdown: A full plant shutdown occurs when the plant is not able to produce any finished water that meets the drinking water permit requirements.
   3. Substantial Completion: As defined in Section 00 72 00 Part 14.5.

1.05 SPECIFIC WORK CONSTRAINTS ON SEQUENCE AND SCHEUDLING OF WORK

A. Escort Vehicle Requirement:
   1. Construction equipment and material deliveries to the CCWTP that require a vehicle larger than a US GVWR Class 2B vehicle or single axle trailer require a contractor provided escort vehicle up and down City Creek Canyon Road. Escort vehicle shall use flashing hazard lights and a loudspeaker to alert people within the canyon of the oncoming vehicles. Contractor shall also provide an electronic marquee at the entrance to City Creek Canyon Road and at the CCWTP to alert the public of large vehicle traffic within the canyon.

B. Snow Removal:
   1. Contractor shall remove snow from the work area to allow access by SLCDPU vehicles and pedestrians.

C. Roadway Closure
   1. City Creek Canyon Road closure from the entrance gate to the CCWTP drying beds is permitted starting January 1, 2025 at 6:00 AM, following a closure schedule of Monday @ 6:00 AM through Friday @ 5:00 PM. Occasional closures on weekends are permitted with SLCDPU approval given 14-day notification. No closures are allowed on holidays.

D. Project Milestones:
   1. BRIC Package Early Works Project shall be substantially completed prior to starting work on BRIC package.
   2. Milestone 1: Completion of the New Treatment Building includes the following.
      a. Operations Building
         1) New standby generator and diesel fuel tank installed at Operations Building and operational.
         2) Operations building standby feeder run to feed Operations Building.
      b. Backwash storage tank
         1) Existing I/O and camera at Backwash Storage Tank transferred to New Treatment Building.
      c. New Treatment building
         1) Treatment Building and associated equipment commissioning complete and operational.

3. Milestone 2: Demolition of Filter Building, Clarifier Modifications, and New Septic Treatment System Complete.
    a. Demolition of filter building.
    b. Existing Clarifier electrical utility feed replaced with standby electrical feed provided from Treatment Building.
    c. New Septic Tank Treatment and Drain Field operational.
4. Milestone 3: Completion of Fluoride Building Addition and Perimeter Drain Pump Station.
    a. Fluoride Building addition complete and facility operational.
    b. Perimeter drain pump station operational.

E. Utilize the following table for construction sequencing planning. The table includes existing pipe description, where the pipe extends from and to, and the until milestone completion it shall remain operational.

Table 1 Existing Yard Piping to Remain Operational

Pipe (Existing)	From (Existing)	To (Existing)	Shall Remain in Operation Until:	Milestone/Notes
36-inch Raw Water (RW)	Plant Intake	Operations Building	New Treatment Plant Commissioned	Milestone 1
24-inch Backwash (BW)	Backwash Tank	Filter Building	New Treatment Plant Commissioned	Milestone 1
Morris 21-inch Filtered Water (FW)	Filter Building Clearwell	21-inch (FW) Morris Pipeline	New Treatment Plant Commissioned	Milestone 1
City 21-inch Filtered Water (FW)	Filter Building Clearwell	21-inch (FW) City Pipeline	New Treatment Plant Commissioned	Milestone 1
12-inch Recycle Water (RCW)	Waste Backwash Clarifier/Recycle Pump Station	Operations Building	New Treatment Plant Commissioned	Milestone 1
12-inch Sludge (SL)	Operations Building Drainpipe	Waste Backwash Clarifier	New Septic Tank and Drain Field Commissioned	Milestone 3
8-inch Plant Utility Water (UW1)	Filter Building	Operations Building	New Treatment Plant Commissioned	Milestone 1
30-inch Drain (DR)	Filter Building North and South Troughs/Junction Box	Waste Backwash Clarifier	New Treatment Plant Commissioned	Milestone 1
8-inch Groundwater Return (GW)	Groundwater Sump/Pump	Plant Intake Pentagon	New Plant Groundwater Sump/Pump Commissioned	Milestone 3
Chemical Ductbank pipes (CEM 6x)	Operations Building	Filter Building	New Plant Commissioned	Milestone 1
6-inch Gray Water (GW)	Operations Building	Septic Tank/Drain Field	New Septic Tank and Drain Field Commissioned	Milestone 2

F. The Treatment Plant shall remain online and unaffected by the Contractor's activities except for the shutdowns shown in Table 2. Table 2 describes construction items, plant shut down allowances, bypass pumping requirements, and bypass pumping maximum flow rates for scheduling and constructing the work.

Table 2 Construction Allowable Shutdowns

Construction Item	Plant Shutdown Allowed	Bypass Pumping Required	Bypass Pumping Maximum Flow Rate	Notes
36-inch Raw Water Pipe (RW) tie in	No	Yes	4.4 mgd	From Plant Intake to upstream of Operations Building Parshall Flume.
12-inch Recycled Water Pipe (RCW) tie in	No	Yes	450 gpm (10% of RW flow to meet FBRR)	From Existing Recycle Pump Station at Waste Backwash Clarifier to Plant Raw Water Intake 1. Winter (October – March) 2-day clarifier/recycle pump station shutdown allowed. 2. Summer (April – September) 1-day clarifier/recycle pump station shutdown allowed.
Clarifier Decant 12-inch Pipe (RCW) and Recycle Pump Replacement	No	Yes	450 gpm (10% of RW flow to meet FBRR)	From clarifier to raw water intake (bypass recycle pump station) 1. Winter (October – March) 2-day clarifier/recycle pump station shutdown allowed. 2. Summer (April – September) 1-day clarifier/recycle pump station shutdown allowed.
Clarifier Rake Mechanism Replacement, Dome Installation, PLC Cabinet Relocation	No	Yes	20,010 gpm (backwash at 23 gpm/sf)	From collection box to manhole 2 (first manhole downstream of clarifier). 1. Winter (October – March) 2-day clarifier/recycle pump station shutdown allowed. 2. Summer (April – September) 1-day clarifier/recycle pump station shutdown allowed.
36-inch Drainpipe (OF) tie into Waste Backwash Clarifier	No	Yes	20,010 gpm (backwash at 23 gpm/sf)	From existing collection box to clarifier 1. Winter (October – March) 2-day clarifier/recycle pump station shutdown allowed. 2. Summer (April – September) 1-day clarifier/recycle pump station shutdown allowed.
36-inch Drainpipe (OF) tie into Waste Backwash Clarifier	No	Yes	20,010 gpm (backwash at 23 gpm/sf)	From new junction box to existing collection box
24-inch Filtered Water (FW) Pipe tie into Existing 21-inch Morris Pipeline	No	No	NA	Tying into existing 21-inch Morris Pipeline is not possible while plant is operating in direct filtration. The new treatment plant must be commissioned and operational.
24-inch Filtered Water (FW) Pipe tie into Existing 21-inch City Pipeline	No	No	NA	New Treatment Plant must be ready to be commissioned prior to tying into City Pipeline. Utilize Morris Pipeline connection to keep direct filtration plant operating while tying into City Pipeline.
12-inch Solids Pipe tie in	No	No	NA	Solids line shall be available to receive solids at any time except for the following: 1. Winter (October – March) 2-day clarifier shutdown allowed. 2. Summer (April – September) 1-day clarifier shutdown allowed.

Construction Item	Plant Shutdown Allowed	Bypass Pumping Required	Bypass Pumping Maximum Flow Rate	Notes
24-inch Backwash Tank Pipe tie in	No	No	NA	Water shall always be available for backwashes. If used, temporary pipes shall be 24-inch diameter and shall be capable of conveying 20,000 gpm from existing Backwash Tank at existing available head. 1. Winter (October – March) 2-day backwash tank shutdown allowed. 2. Summer (April- September) 1-day backwash tank shutdown allowed.
Sodium hypochlorite, ferric chloride, and PEC tie in	No	No	NA	No full shutdowns of chemicals are allowed.
Fluoride Building	No	No	NA	Filter Building demolished prior to starting work in Fluoride Building. Fluoride treatment system can be off-line no more than 6 months.

1.06 CONTINUOUS OPERATION OF EXISTING FACILITIES

A. Conduct the Work and provide temporary facilities required to keep the existing plant continuously operational.

B. Do not remove or demolish existing facilities required to keep the existing plant operational at the capacities specified until the existing facilities are replaced by temporary, new, or upgraded facilities or equipment.
   1. Test replacement facilities to demonstrate operational success prior to removing or demolishing existing facilities.

C. Temporary Standby Power must be onsite and operational before demolition of any equipment tied to existing standby generator operation in operations building.

1.07 OPERATIONS AND MAINTENANCE ACCESS

A. Provide safe, continuous access to process control equipment for plant operations personnel.

1.08 UTILITIES

A. Provide advance notice to, and utilize services of, Blue Stake for location and marking of underground utilities operated by utility agencies other than the Owner.

B. New yard utilities were designed using existing facility drawings.
   1. Field verification of utilities locations was not performed during design. Contractor shall pothole existing utilities to confirm exact location prior to ordering materials for project work and shall not rely on the identification or location of utilities shown on the Drawings.
   2. Services crossed or located nearby by new yard utilities may require relocation and possible shutdowns.
   3. Pipe alignments as indicated on the Drawings.

1.09 LIMITATIONS OF CONSTRUCTION

A. The following constraints shall be followed during construction, commissioning, startup, and testing.
   1. Always protect-in-place existing 36-inch Sedimentation Bypass Piping and Flocculation Basin Inlet Channel. No shutdowns of the channel and pipe are allowed.
   2. At all times, allow CCWTP access via City Creek Canyon Road for plant staff and service vehicles.
   3. Coordinate with SLCDPU to allow CCWTP access via City Creek Canyon Road for chemical deliveries as often as once per month.

1.10 RESTRICTIONS (BEYOND MAINTAINING PLANT OPERATIONS)

A. Milestone 1
   1. Temporary Dewatering shall always be provided until perimeter drain collection piping and pump station is operational.
   2. Standby plant power shall always be maintained. The following are the only acceptable times for standby power to be unavailable:
      a. One 3-hour maximum duration shutdown allowed for tie in of a temporary generator to the existing operations building ATS to allow for demo of the existing generator and diesel tank.
      b. One 3-hour maximum duration shutdown allowed for tie-in to new switchgear. Shutdown will include removal of the temporary generator and connection to the new switchgear with the new generator and diesel tank operational back to the existing operations building ATS.
   3. Communication with the existing networking equipment and controllers shall not be interrupted during construction activities. The new fiber optic cables shall be tested and approved prior to startup, testing, and commissioning of the new equipment. The existing fiber optic cabling may be abandoned or demolished only after the new systems are tested, commissioned and brought on-line for water production.

B. Milestone 2
   1. Temporary dewatering shall always be provided until perimeter drain collection piping and pump station is operational.
   2. Clarifier
      a. Shutdown for rake replacement shall occur during the same shutdown for panel relocation.

C. Milestone 3
   1. Temporary dewatering shall always be provided until perimeter drain collection piping and pump station is operational.
   2. Fluoride treatment system shall only be offline for 4 months or less.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

APPENDIX A

"Method of Procedure" (MOP)

Instructions and Forms

Definition and Purpose

"Method of Procedure" (MOP) is a detailed document submitted by the Contractor to request process shutdown(s), utility tie-in(s), work in areas that may risk unanticipated outages, or flow diversions to accommodate site construction activities during a project. Such activities may include (but are not limited to) new tie-ins to utilities or structures, mechanical modifications to process piping or equipment, demolition, bulkhead installation, and cleaning processes.

The MOP provides a detailed plan to the Owner and Engineer that describes specific aspects of the work including purpose, time of execution, and anticipated impacts on treatment processes. The MOP also includes contingency measures and provisions for rapid closure in the event that shutdown or work progress difficulties are encountered. Information from relevant trades associated with the requested shutdown, diversion, or tie-in is also included.

The Owner should use the information within the MOP to define operational procedures and methods to safely and successfully assist the Contractor.

MOP Process Summary

WHO	STEP		TIMING
Contractor	1.	Identify MOPs needed on MOP Log and Baseline Schedule.	7 days prior to Preconstruction Meeting
Contractor, Owner, Engineer	2.	Pre-MOP Meeting.	More than 28 days prior to work
Contractor	3.	Submits MOP.	No later than 28 days prior to work
Owner	4.	Reviews MOP.	
Owner	5.	MOP finalized.	7 days prior to work
Contractor	6.	Complete Readiness Checklist.	5 days prior to work
Contractor	7.	Complete Safety Checklist.	Just prior to commencing work
Contractor	8.	Complete Work.	
Contractor	9.	Update MOP Log and Progress Schedules.	Monthly

MOP Process Detail

STEP 1. Identifies MOPs needed on MOP Log and Baseline Schedule.

Contractor submits a preliminary list of anticipated project MOPs on MOP Log. MOPs identified but not limited to those shutdowns, diversions, or tie-ins described in the Contract Documents. Incorporate MOPs as tasks in Baseline Schedule. Date scheduled MOPs to coincide with the appropriate construction activities.

STEP 2. Pre-MOP Meeting.

Contractor requests a Pre-MOP Meeting with the Owner and Engineer to discuss the nature of the shutdown, diversion, or tie-in, and to gather the information necessary to complete the MOP Form. The pre-MOP meeting may be waived by the Owner or Engineer if the work is deemed to be minor.

STEP 3. Submits MOP.

Contractor completes the MOP Form and submit 3 copies for approval to the Engineer/Owner.

STEP 4. Reviews MOP.

Engineer/Owner distributes MOP Form for review by the Owner's Construction Coordinator, O&M Representative, and Engineer's Project Representative. Review MOP Form for completeness, accuracy, compliance with both the construction schedule, constraints defined in contract documents, and to ensure that the requested work does not negatively impact plant operations or other concurrent project activities. Additional information may be requested to better understand the nature of and method for completing the Work.

STEP 5. MOP finalized.

Once the MOP is agreed to by all parties, the MOP will be finalized by signature. Copies are distributed to the Owner, Engineer, and Contractor.

STEP 6. Complete Readiness Checklist.

Contractor verifies everything is ready for the work.

STEP 7. Complete Safety Checklist.

Contractor ensures safety.

STEP 8. Complete work.

Contractor complete work.

STEP 9. Update MOP Log and Progress Schedules.

Contractor updates MOP Log weekly and distributes at the regularly scheduled construction progress meetings.

METHOD OF PROCEDURE (MOP) FORM

Owner:		**Date:**	
Contractor:		**City Project No.:**	
Project Name:		**Submittal No.:**	
Submittal Title:		**Spec/Dwg. Reference:**	

MOP #	Task Title *(Provide <10 word title)*:	Submittal Date: *(No later than 28 days prior to work)*

SCHEDULE OF WORK ACTIVITY START: *(Date/Time)* END: (Date/Time)

REQUESTOR:

PRIMARY POINT OF CONTACT:	PHONE/PAGER:
SECONDARY POINT OF CONTACT:	PHONE/PAGER:

NOTIFY	☐	Control Room, Phone	☐	Security, Phone

BUILDING: LOCATION OF WORK FLOOR/LEVEL:

DESCRIPTION OF WORK: *(Provide sufficient details on process isolation, work sequencing, and safety (i.e., control of significant hazards unique to the work) to demonstrate an understanding of the work and how it will be completed within the constraints, and its impact on the processes and facility.)*

Task Summary:

Processes Affected:

Trades Affected:

WORK PLAN:

Work Sequencing:

Process Isolation:

Spill Prevention Plan:

Contingency Plans:

CRITICAL EQUIPMENT/TOOLS: *(pumps and discharge hoses with correct fittings, blind flanges and pipe plugs, no-hub fittings, properly sized electrical service components, generators, portable lighting, chlorine for potable water pipe breaks, etc.)*

☐	Acoustic Ceiling/or Walls Access	☐	Excavation Permit	☐	Lock Out/Tag Out
☐	Chemical Use Approval	☐	Fire Sprinkler Impairment	☐	Life Safety Systems
☐	Confined Space Permit	☐	Flammable Materials	☐	Roof Protocol
☐	Critical Lift Plan	☐	Flush / Discharge	☐	Work After Dark
☐	Energized Electrical Work	☐	High Pressure Test	☐	
☐	Elect. Panel Schedules	☐	Hot Work/Open Flame	☐	

EXISTING SERVICE(S) AT RISK:							
☐	Breathing Air	☐	Elect Normal	☐	Process Access	☐	Telephones
☐	Chemical Distribution	☐	Fire Protection	☐	Safety Showers	☐	UPS
☐	City Water	☐	HVAC	☐	SCADA	☐	VAX/DATA
☐	Communication	☐	Inert Gas	☐	Security	☐	
☐	Domestic Drain	☐	Instrument - Air	☐	Solvent Drain	☐	
☐	Elect-Bus Duct	☐	Life Safety System	☐	Specialty Gases	☐	
☐	Elect Emergency	☐	Natural Gas	☐	Storm Drain	☐	

REVIEWER'S INSTRUCTIONS / COMMENTS:

☐	PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK:

	Full Name (printed)	Signature	Phone	Date
Submitted By				
System Owner				
Reviewer (if needed)				
Reviewer (if needed)				
Reviewer (if needed)				

READINESS CHECKLIST

(5 days prior to work)

Checklist provided as a guide but is not all inclusive.

1. Confirm all parts and materials are on site:

   _____

   _____

2. Review work plan:

   _____

   _____

3. Review contingency plan:

   _____

   _____

SAFETY CHECKLIST

(Just prior to commencing work)

Checklist provided as a guide but is not all inclusive.

4. Location awareness:
    a. Emergency exits:
    b. Emergency shower and eyewash:
    c. Telephones and phone numbers:
    d. Shut-off valve:
    e. Electrical disconnects:
5. Inspect work area:
    a. Take time to survey the area you are working in. Ensure that what you want to do will work. Do you have enough clearance? Is your footing secure? Do you have adequate lighting and ventilation? Are surrounding utilities out of the way for you to perform your work?
6. SDS (Safety Data Sheets):
    a. Understand the chemicals and substances in the area you are working in by reading the SDS.
7. Lockout/Tagout Procedure:
    a. Lockout/tagout energy sources before beginning work.
    b. Make sure all valves associated with the work are locked out and tagged out on each side of the penetration.
    c. Make sure the lines are depressurized.
8. Overhead work:
    a. Use appropriate personal protective equipment; i.e., safety harness, lifeline, etc.
    b. Select appropriate tie-off points; i.e., structurally adequate, not a pipe or conduit, etc.
    c. Spotter assigned and in position.
    d. Pipe rack access; i.e., check design capacity, protective decking or scaffolding in place, exposed valves or electrical switches identified and protected.
9. Safety equipment:
    a. Shepherd's hook.
    b. ARC flash protection.
    c. Fire extinguisher.
    d. Other: .
10. Accidents:
    a. Should accidents occur, do not shut off and do not attempt to correct the situation, unless you are absolutely positive that your action will correct the problem and not adversely affect other people or equipment.
11. Review process start-up documents:
    a. In the event the system is shutdown, the Control Center should have a working knowledge of the process start-up procedures in order to deal effectively with unforeseen events.

12. Evacuation procedures:
    a. Do not obstruct evacuation routes.
    b. Take time to survey the area for evacuation routes.

Method of Procedure (MOP) Log

Sample

MOP Number	Task Title	Date Requested	Date Approved	Date Work Planned	Work Completed (yes/no)
001					
002					
003					

END OF SECTION

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SECTION 01 14 19

USE OF SITE

PART 1 GENERAL

1.01 SUMMARY

A. The OWNER's operating personnel will be responsible for operating the existing treatment plant throughout the execution of this contract. Equipment presently installed in the treatment plant must be available to plant personnel at all times for use, maintenance, and repair. If it is necessary in the course of operating the plant, for the CONTRACTOR to move his equipment, materials, or any material included in the work, he shall do so promptly and place that equipment or material in an area which does not interfere with the plant operation. The CONTRACTOR shall not adjust or operate serviceable or functioning equipment or systems except as specifically required by this contract.

B. The existing treatment plant will remain in operation throughout the execution of this contract. The CONTRACTOR shall schedule and conduct his work to minimize necessary shutdowns and interference with normal plant operations and maintenance.

C. The CONTRACTOR shall notify the Construction Manager, in accordance with Section 01 12 16, 1 week in advance of the time it is necessary to take out of service any existing tank, pipeline, channel, electrical circuit, equipment or structure. The CONTRACTOR shall be responsible for providing whatever temporary piping, pumping, power, and control facilities as are required to maintain continuous plant operation and complete treatment except as otherwise specified. The integrity of existing plant utilities shall be maintained by the CONTRACTOR at all times.

END OF SECTION

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SECTION 01 31 13

COORDINATION

This specification changes a portion of APWA Standard Specification Section 01 31 13. All other provisions of the Section remain in full force and effect. This project is in City Creek Canyon so it will be necessary to have a good coordination effort.

Add the following Article to Part 1 (page 100):

1.8 PUBLIC AGENCIES AND UTILITY PERSONNEL TO CONTACT

A. Utility Companies: Utility companies generally require a minimum of 48 hours notice if their utility requires location, relocation or protection. Contact the following individuals to coordinate. (Please note Contractor must contact **Blue Stakes** before digging, phone **(801) 208-2100**.)

1. The Salt Lake City Department of Public Utilities: Tammy Wambeam, G.I.S. & IT Manager, (801) 483- 6746 – Mapping Questions
2. The Salt Lake City Department of Public Utilities to schedule inspection and survey of project of installed sanitary sewer mains, storm drain mains, street lighting and water mains prior to backfilling fittings, valves, washouts, etc.: Call (801) 483-6727.
3. The Salt Lake City Department of Public Utilities Industrial Storm Program Coordinator, Greg Archuleta, (801) 483-6821
4. The Salt Lake City Department of Public Utilities Street Lighting Program Manager, David Pearson, (801) 483-6738

1.9 COORDINATION WITH SALT LAKE DEPARTMENT OF PUBLIC UTILITIES

A. Construction equipment and material deliveries to the CCWTP that require a vehicle larger than a US GVWR Class 2B vehicle or single axle trailer shall be coordinated the Salt Lake City Department of Public Utilities Watershed Manager. Provide a minimum of 72 hours notice to the watershed manager prior to scheduled delivery.

1. The Salt Lake Department of Public Utilities Watershed Manager, Patrick Nelson, (801) 483-6889.

1.10 COORDINATION WITH PUBLIC RELATIONS COORDINATOR

A. Public Relations Coordinator: Provide a minimum of 72 hours notice to the public relations coordinator for all work that impacts the public's use of City Creek Canyon Road. Examples include transporting of excavation equipment or haul trucks, concrete trucks, excavations, etc. The public relations coordinator will share this information with the public via a project website.

1. Kimley-Horn: Jordan King, Project Relations Coordinator, (385) 881-6528

END OF SECTION

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SECTION 01 32 17

BASELINE AND PROGRESS SCHEDULES

PART 1 GENERAL

1.01 PURPOSE

A. The OWNER is committed to delivering quality, cost-effective infrastructure to its customers in a timely manner. One of the most important tools the OWNER uses to achieve this goal is accurate, updated, current schedules for its capital projects. Accurate and updated schedules allow the OWNER to effectively track and manage its projects both in aggregate (at the program or OWNER-wide level) and project-by-project.

B. The OWNER's goal is to take every reasonable step to ensure that projects finish on time and within budget. Project schedules are the fundamental building blocks to planning and executing projects efficiently and on time. These schedules are best prepared by those closest to the work. Because the vast majority of capital project delivery at the OWNER is performed by CONTRACTOR, it is critical that CONTRACTOR prepare schedules as part of performing their work for the OWNER.

C. This Schedule Guidance Document is designed to guide CONTRACTOR in preparing and submitting acceptable schedules for use by the OWNER.

1.02 APPLICABILITY AND BASIC REQUIREMENTS

A. CONTRACTOR is responsible for preparing schedules as defined herein and as required in their contracts. A waiver allowing a CONTRACTOR not to prepare a schedule in accordance with this Schedule Guidance Document may only be granted by the OWNER or designee.

B. There are three (3) basic elements to schedule submittals.
   1. Baseline Schedule: Initial schedule submitted before work begins that will serve as the baseline for measuring progress and departures from the schedule. The Baseline Schedule is prepared by the CONTRACTOR at the beginning of the project and submitted to the OWNER for review and approval.
   2. Progress Schedule: Monthly submittal of a Progress Schedule documenting progress on the project and any changes anticipated. The Progress Schedule is prepared monthly by the CONTRACTOR and submitted to the OWNER.
   3. Schedule Narrative: Concise narrative that highlights changes in the schedule, expected delays, key schedule issues, etc., along with a cash flow graph or summary table. The Schedule Narrative is submitted to the OWNER monthly in conjunction with the Progress Schedule.

C. The schedules required herein will be prepared using the following software (or saved down in the following version) in order to be compatible with the OWNER's schedule system, unless prior permission to use another software is requested and granted by the OWNER.
   1. Primavera Project Planner (now owned by Oracle) version 8.2 or later
   2. or Microsoft Project.

D. Completion time and all specific dates given in the Contract Documents, and sequencing requirements described in Section 01 12 16, shall be shown on the schedule. Activities making up the critical path shall be identified.

1.03 BASELINE SCHEDULE

A. General: The CONTRACTOR will develop a cost loaded schedule using the software version required in Section 1.2 and the Critical Path Method (CPM).
   1. The OWNER will inform the CONTRACTOR of the Project Code (Project Number) for the Project. The file naming convention is demonstrated in the examples below.
      a. Baseline
         Format. ProjectCode (project number)_DocumentType_Date_
         Example. 1701_ScheduleBaseline_03162017.XER
      b. Monthly Update
         Format. ProjectCode (project number)_DocumentType_Date_
         Example. 1701_ScheduleUpdate_03162017.XER
      c. Monthly Schedule Narrative
         Format. ProjectCode (project number)_DocumentType_Date_
         Example. 1701_ScheduleNarrative_03162017.DOC
   2. The approved Baseline Schedule is a part of the contract by reference. The CONTRACTOR has the sole responsibility to correct any latent defects in the Baseline Schedule and perform to the subsequently revised schedule.
   3. The CONTRACTOR will use the Baseline Schedule to coordinate and monitor the work (including the activities of subcontractors, equipment vendors and suppliers).
   4. The CONTRACTOR must keep a copy of the approved Baseline Schedule.

B. Schedule Work Breakdown Structure and Activities
   1. Work Breakdown Structure (WBS): The OWNER's Work Breakdown Structure is designed to meet the basic reporting needs for the OWNER's financial and tracking systems. The CONTRACTOR's project-specific WBS should work within this basic framework and provide additional detail to efficiently deliver and track the work.
      a. WBS elements that are definitely not a part of the scope of services need not be included in the schedule. Note that as many subtasks and activities as desired may be included underneath the WBS elements.
   2. Activities: Activities are the discrete elements of work that make up the schedule. They should be organized underneath the umbrella of the WBS as described in Exhibit A.
      a. The following information should be provided for each activity:
         1) Activity ID Number
            a) Use a four-digit number left justified in the activity I.D. field.
            b) Alphanumeric activity numbers are NOT acceptable.
      b. Activity Description
         1) Activity descriptions should adequately describe the activity and in some cases the extent of the activity. Examples of acceptable descriptions might include "install pipeline between Avenue A and Avenue B", "water line route layout", etc.).

c. Activity Durations
    1) The activity duration will be based upon the physical amount of work that is to be performed for the stated activity and are limited to 20 working days. If work is to exceed 20 days, then break the work down so the work will be completed within a 20-day time frame.
    2) The intent of this requirement is to ensure that the activities are segmented sufficiently to adequately track progress.
d. Activity Start and Finish Dates
    1) Activity start and finish dates will only be accepted if calculated by the software.
    2) Actual activity start and finish dates may not be assigned in a baseline. However, they must accurately be assigned in the working version of the schedule (see Section 4 Progress Schedule).
e. Activity Dependencies
    1) All activities will be logically tied with a predecessor and a successor. The only exception to this rule will be for the project start and project finish milestones.
f. Milestone Activities
    1) The following milestone activities (i.e., important events on a project that mark critical points in time) are of particular interest to the OWNER and should be reflected in the Project Schedule for all phases of work, as applicable. Notice to Proceed (Construction)
    2) Draft Baseline Schedule submittal
    3) Preparation and submission of shop drawings, submittals, and any required re-submittals (if applicable)
    4) Mobilization
    5) Fabrication and delivery of equipment and materials (if applicable)
    6) Substantial Completion
    7) Construction Complete

C. **Baseline Schedule Development: The** CONTRACTOR will designate an authorized representative (Project Scheduler) responsible for developing and updating the schedule and preparing reports. It is recommended that a qualified scheduler develop the Baseline Schedule.
1. The CONTRACTOR's initial schedule submittal will contain NO progress and represent the planned work for the duration of the project. Once approved by the OWNER, this schedule will become the baseline against which all future variance analysis will be performed.
2. The use of activity external constraint dates and lags on relationships is discouraged unless specified or approved by the OWNER. An example of an external constraint date is "concrete placement will begin no later than January 1." The reason for this requirement is that it creates an artificial (rather than calculated) critical path.
3. The Baseline Schedule will consider delivery lead times, construction and access constraints and the coordination of construction with OWNER operations.
    a. **Safety Requirements:** Schedule performance should never take precedence over safety. Project schedules must allow work to be performed in a safe manner.
        1) The CONTRACTOR cannot reduce safety or worker protection in order to shorten schedules, recover lost time or accelerate the work.

b. **Inclement Weather**: Refer to climatology data for anticipating work that can be affected by inclement weather. Historical rain days can be reviewed from the following web site: http://www.noaa.gov/climate

D. Changes to Approved Baseline Schedule: The approved Baseline Schedule is the basis for measuring progress on the project (see Paragraph 1.4, Progress Schedule). As such, the CONTRACTOR should develop the Baseline Schedule considering the realistic delivery of the work tasks and likely constraints.

1. Total and free float is not for the exclusive use or benefit of either the OWNER or the CONTRACTOR, but is a resource available to both parties for the benefit of the project on a first needed basis. Changes to the Baseline Schedule will only be considered after all float has been consumed.
2. Changes to the approved Baseline Schedule may only be considered under limited circumstances. If warranted, any changes will require PRIOR approval by the ENGINEER's Designee and OWNER's Program Manager. Project circumstances that could be considered by the OWNER as potentially warranting re-baselining include the following:
   a. Change Orders to the contract affecting the scope of the work to be performed and the associated schedule completion date

1.04 PROGRESS SCHEDULE

A. As described in Paragraph 1.3, the Baseline Schedule is used to coordinate and monitor the work. The CONTRACTOR is required to keep a copy of the approved Baseline Schedule.

B. The Progress Schedule is simply a copy of the approved Baseline Schedule that will be statused monthly. In other words, progress on the project will be shown monthly as an update of the schedule that will be compared to the approved Baseline Schedule.

C. Note that the Progress Schedule will be statused (data date) through month end, although the submittal date must comply with Paragraph 1.6 of this section.

1. **Progress Updates:** The CONTRACTOR should show on the Progress Schedule updates of the following:
   a. The actual dates that activities start
   b. The actual dates that activities finish
   c. The remaining duration of activities in progress
   d. The percent complete of all activities on the schedule (0 percent to 100 percent complete)
2. **Schedule Narrative**: The Progress Schedule will be accompanied monthly by a concise Schedule Narrative that explains the submitted schedule. The purpose of the Schedule Narrative is to:
   a. Speed review time
   b. Explain variances from Baseline on critical path activities
   c. Explain to the OWNER logic changes and potential schedule conflicts related to dependences.
   d. Concisely summarize the projected cash flow for the project based on the statused schedule.

3. If the project is on schedule, and no significant issues related to schedule exist, then the Schedule Narrative is extremely brief. On the other hand, if the project is falling behind, and/or there are significant conflicts and obstacles to meeting the Baseline Schedule, then the Schedule Narrative should describe the issues and what steps will be necessary for the project to recover. Sharing this information ensures that the entire project team will be aware of the issues and have opportunity to assist, where applicable.

1.05 ADDITIONAL GUIDANCE APPLICABLE TO CONSTRUCTION SCHEDULES ONLY

A. In addition to the requirements in Sections 1.1 – 1.4 of this Schedule Guidance Document, the CONTRACTOR's schedule will include the following.
   1. Schedule of Value Pay Items: Schedule of Values Pay Items (Work) shall be loaded into the scheduling software using the labor, materials, and equipment resource types showing the quantity of Work to be done along with the corresponding value of the Work measured in dollars.

1.06 SUBMITTAL OF SCHEDULES

A. Submittal File Formats: Every time that a schedule or report is submitted (baseline and monthly progress) the following file formats are required.
   1. Baseline Schedule: Submit the schedule in native file format (see below).
      a. Also submit a .pdf of the bar chart schedule consisting of the following columns:
         1) Activity ID
         2) Activity Name
         3) Duration
         4) Start Date
         5) Finish Date
         6) Float
         7) Cost
   2. Progress Schedule: Submit the schedule in native file format (see below).
      a. Also submit a .pdf of the bar chart schedule consisting of the following columns:
         1) Activity ID
         2) Activity Name
         3) Physical Percent Complete
         4) Duration
         5) Start Date
         6) Finish Date
         7) Total Float
         8) Remaining Total Cost
   3. Schedule Narrative: Submit the schedule narrative in .doc format.
   4. Native Schedule File Formats: The native file structure is to save the schedule as follows:
      a. In Primavera 6, save the file as an .XER file.
      b. In Microsoft Project, save the file as an .MPP file.

B. **Submittal Process**: All submittals of schedules must be made to the ENGINEER's Designee. Draft project Baseline Schedules must be submitted within thirty (30) calendar days after the formal Notice to Proceed from the OWNER. All schedules must be submitted in their native format (.XER file or .MPP) as well as in a PDF format. The OWNER will review, accept or reject the schedule within five (5) days of submittal.

1. Once the Baseline Schedule has been accepted, Progress Schedule updates will be due monthly prior to the monthly progress meetings.

END OF SECTION

EXHIBIT A – OWNER WORK BREAKDOWN STRUCTURE

WBS shown in gray are reserved for the OWNER. WBS shown in blue are reserved for CONTRACTOR.

WBS Number	Name
1	**Pre-Design**
1.1	Project Planning & Development
1.2	Design Consultant Procurement
1.3	RFP Development
1.3.1	OWNER Review Process & Consultant Negotiations
1.3.2	Consultant Selection
2	**Project Design**
2.1	Survey and Geotechnical
2.2	Design
2.2.1	30% Design
2.2.2	60% Design
2.2.3	90% Design
2.3	Bid Documents
3	**Bidding**
3.1	Bid & Award
4	**Contract**
4.1	Contract Negotiation
5	Project Construction
5.1	Mobilization
5.2	Construction
5.2.1	Task 1
5.2.2	Task 2
5.2.3	Task 3
5.2.4	Task 4
5.2.5	Task 5
5.2.6	Task 6
5.2.7	Task 7
5.2.8	Task 8
5.2.9	Task 9
5.2.10	Task 10
5.3	Testing and Commissioning
5.4	Construction Services

WBS Number	Name
6	Closeout
6.1	Closeout

SECTION 01 32 23

PART 1 GENERAL

1.01 SURVEY AND LAYOUT

A. The Owner will establish reference benchmarks and baselines as specified.

B. From the information provided, the Contractor shall develop and make such additional surveys as are needed for construction, such as control lines, slope stakes, batter boards, stakes for pipe locations and other working points, lines, and elevations.

C. Contractor shall reestablish reference benchmarks and survey control monuments destroyed by his operations at no cost to the Owner.

D. Survey work shall be performed under the supervision of a licensed land surveyor or registered civil engineer. Contractor shall submit Surveyor's name, certificate of assurance, license number, and schedule of values prior to starting work.

END OF SECTION

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SECTION 01 32 33
PHOTOGRAPHIC DOCUMENTATION

PART 1 GENERAL

1.1 SUMMARY

A. This Section specifies progress photographs to be provided for pre-construction, during construction, and post-construction.

PART 2 SUBMITTALS

A. Photographs shall be submitted in accordance with Section 01 33 00 - Submittal Procedures.

PART 3 PRODUCTS

1.1 PHOTOGRAPHS

A. Photographs shall be taken using a digital camera. Photographs shall be in color and shall have a minimum image area of [1600 X 1200] pixels.

B. Upload, maintain, and organize the photographs monthly using a commercially available photo management system. Organize files by area, year, and month. Assign file names that include location by area, direction, description and date taken.

C. Submit photographs in digital format on a monthly basis.

PART 4 EXECUTION

1.1 GENERAL

A. Photographs shall be taken at locations designated by the Owner and Construction Manager.

B. The photographer shall be equipped to photograph interior and exterior exposures, with lenses ranging from wide-angle to telephoto and flash equipment as necessary for interior spaces.

PART 5 PRE-CONSTRUCTION PHOTOGRAPHS

A. The Contractor shall provide preconstruction photographs prior to commencement of work on the Site.

PART 6 CONSTRUCTION PHOTOGRAPHS

A. The Contractor shall provide construction photographs showing the progress of the Work. The photographs shall be taken of such subjects as may be directed by the Owner and Construction Manager.

B. Photographs of all underground piping and structures prior to backfilling. Include associated location information.

PART 7 POST-CONSTRUCTION PHOTOGRAPHS

A. Take the number of exposures specified until Final Acceptance of the Work. Locations shall be designated by the Owner and Construction Manager.

PART 8 REQUIRED NUMBER OF PHOTOGRAPHS

A. For the work of this Contract, photographs shall provide the minimum number of photographs as follows:

Category	Number of Photographs
Preconstruction	50
Construction	15 weekly
Acceptance	50

END OF SECTION

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes administrative and procedural requirements for submittals.

1.02 ADMINISTRATIVE REQUIREMENTS

A. General:
   1. Furnish submittal items as specified in the Contract Documents.
   2. Review submittal information to verify it is accurate and fulfills specified submittal requirements before submitting for review and comment.
   3. Edit submittal content to clearly indicate only those items, models, or series of equipment, which are being submitted for review. Cross out or otherwise obliterate extraneous materials.
   4. Ensure there is no conflict with other submittals and notify the Owner's Representative in each case where the submittal may affect the work of another contractor or the Owner.
   5. Coordinate submittals among subcontractors and suppliers including those submittals complying with unit responsibility requirements specified in the Contract Documents.
   6. For each submittal, certify field conditions, compliance with the Contract Documents, and review of the submittal prior to submitting for review.
   7. Designate the installation location within the facility, application, or intended purpose for each submittal item. Review comments are solely applicable to the circumstances designated in the submittal.
   8. Coordinate submittals with the work so that work will not be delayed. Coordinate and schedule different categories of submittals, so that one will not be delayed for lack of coordination with others.
   9. No extension of time will be allowed because of failure to properly schedule, coordinate or compile submittals.
   10. Submittals will be rejected for lack of legibility, lack of coordination, ambiguity, or are incomplete. Incomplete submittals will be returned without review.
   11. Do not proceed with work related to a submittal until the submittal process is complete. This requires that submittals for review and comment be returned to the Contractor stamped "No Exceptions Taken" or "Make Corrections Noted."
   12. If desired, authorize material or equipment suppliers to deal directly with the Owner's Representative regarding a submittal. Such dealings require written authorization from the Contractor and are limited to contract interpretations to clarify and expedite the work.

1.03 DEFINITIONS

A. Action Submittals:
   1. Action Submittals content require review and response by the Owner's Representative before proceeding with incorporating the subject equipment, materials, or procedure into the work.
   2. Review comments on Action Submittals, and perform subsequent actions based on the REVIEW ACTION requirements specified below.

B. Informational Submittals:
   1. Informational Submittals are examined to verify that the specified submittal contents have been furnished as specified.
   2. The Contractor's actions are not contingent on the disposition of review comments on Informational Submittals.
   3. Review comments on Informational Submittals, and perform subsequent actions based on the REVIEW ACTION requirements specified below.

C. Closeout Submittals:
   1. Closeout Submittals consist of documentation that is not available for review at the time Action Submittals are submitted for review or documentation that is typically generated or furnished following incorporation of the equipment, materials, or procedure into the work. Closeout submittals include spare parts inventory listing, spare parts, extra stock materials, special tools and other materials or components that are furnished separate from the installed and completed work.
   2. Review comments on Closeout Submittals, and perform the subsequent actions based on the REVIEW ACTION requirements specified below.

D. Samples:
   1. Samples include partial sections of components, cuts, or containers of materials, color range sets, and swatches showing color, texture and pattern.
   2. Samples may be Action or Informational submittals.

E. Mock-Ups:
   1. Mock-ups are scale representations of items to be constructed as part of the work as required in the Contract Documents.
   2. Mock-ups are Action Submittals.

F. Review Actions:
   1. The following definitions and actions are associated with the REVIEW ACTIONS DEFINED below:
      a. NO EXEPTIONS TAKEN: If the review indicates that the material, equipment or work method complies with the Contract Documents, submittal will be marked "NO EXCEPTIONS TAKEN." Implement the work method or incorporate the material or equipment covered by the submittal.

b. MAKE CORRECTIONS NOTED: If the review indicates limited corrections are required, submittals will be marked "MAKE CORRECTIONS NOTED." Implement the work method or incorporate the material and equipment covered by the submittal in accordance with the noted corrections. Where submittal information will be incorporated in O&M data, provide a corrected copy.

c. AMEND AND RESUBMIT: If the review reveals that the submittal is insufficient or contains incorrect data, submittals will be marked "AMEND AND RESUBMIT." Do not undertake work until the submittal has been revised, resubmitted and returned marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED".

d. REJECTED – SEE REMARKS: If the review indicates that the material, equipment, or work method does not comply with Contract Documents, the submittal will be marked "REJECTED - SEE REMARKS." Do not undertake the work covered by such submittals until a new submittal is made and returned marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" except at your own risk.

1.04 MASTER SUBMITTAL LIST

A. A minimum of five (5) business days following the Notice to Proceed, the Contractor will provide the Owner's Representative a Master Submittal List listing anticipated submittal requirements for the contract.

B. Contractor shall update the list as submittals are completed and transmit to the Owner's Representative. Provide updated list to Owner's Representative monthly.

C. Include the following as a minimum in the updated list:
   1. Submittal number.
   2. Date submitted.
   3. Requested time for return of comments.
   4. Special requests, if any, for that particular submittal.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 SUBMITTAL PROCEDURES

A. General:
   1. Owner's Representative will review submittal information and indicate a REVIEW ACTION. Review of submittals does not relieve the Contractor of responsibility for performance of the work according to the Contract Documents.
   2. Coordinate submittal transmittal for related elements of work to ensure the submittals are processed as needed to meet the intent of the work and that delays are minimized.
   3. Submittal review activity will be prioritized based on the order received unless otherwise requested by the Contractor.
   4. Submittal sequencing should coincide with the Construction Schedule in Section 01 32 17 - Construction Progress Schedule.

5. A review duration of 21 calendar days is allotted for each submittal, from the date of receipt by the Owner's Representative to the date of return to the Contractor.

B. Submittal Preparation:
   1. Excepting, mock-ups, spare parts, physical samples, and other items that cannot be converted to electronic media, furnish submittal contents electronically in a searchable PDF format.
      a. Include a table of contents and labeled divider sheets that are coordinated with the table of contents.
      b. Diagrams, drawings, pictures, and illustrations presented with a consistent orientation.
   2. Shop Drawings, Samples and Mock-ups
      a. Submit one electronic copy per the requirements described above and the following:
         1) Shop Drawings: one (1) reproducible and two (2) prints for job site reference. One marked up print will be returned to the Contractor when the review is complete.
         2) Samples: 2 samples
         3) Mock-up: As required by individual specification
         4) Demonstrations: As required to facilitate installation and inspection
      b. Reference applicable specifications for additional requirements

C. Submittal Completeness:
   1. Submittals without all required information are not acceptable and may be marked "REJECTED" and returned without review.
   2. For a submittal to be deemed complete, provide the information required below and specified in specification sections, including those elements in the special transmittal procedures where required.

D. In the event of the need to "revise and resubmit", provide a complete stand-alone submittal with corrections, revisions, and new information clearly identified.

E. Resubmit changes to submittals that require a stamp and signature by a licensed engineer or other certification with the requisite stamp and signature or certifications.

3.02 TRANSMITTAL PROCEDURE

A. General:
   1. Equipment and Material Submittals: Unless otherwise specified, complete the Transmittal Form 01 33 00-A - Submittal Transmittal Form specified in Section 01 99 90 - Reference Forms
   2. Operation and maintenance manuals, information and data Submittals: Complete the Transmittal Form 01 78 23-A - Operation and Maintenance Transmittal Form specified in Section 01 99 90 - Reference Forms.
   3. Unless otherwise specified, submittals regarding material and equipment shall be submitted electronically using a document control program/website such as Procore or SLCDPU's Project Central.

B. SUBMITTAL REGISTER

1. List submittals required by Contract Documents on the attached Submittal Register form. Identify CONTRACTOR's need dates and ENGINEER's action dates.
2. SCHEDULED ACTIVITY: If an activity on the Progress Schedule is assigned to the submittal, place the schedule activity number in the "SCHEDULED ACTIVITY" column.
3. SUBMITTAL ITEM No.: Assign to each entry on the Submittal Register a sequential number in the "SUBMITTAL IDENTIFICATION (ITEM NUMBER)" column.
4. REVIEW ACTION: The "REVIEW ACTION" column identifies technical review responsibility of submittal. Review of all products and materials is the CONTRACTOR's responsibility; however, certain specified submittals will also require ENGINEER's review.
    a. If REVIEW ACTION Column is Blank: Identified submittal shall be approved by the CONTRACTOR and then submitted to the ENGINEER for information.
    b. If the "ENGINEER" is Identified in the REVIEW ACTION Column: Identified submittals shall be first approved by the CONTRACTOR and then submitted to the ENGINEER for review.
5. ENGINEER ACTION DATES: This column is for ENGINEER's use to record date submittal was received and the action code assigned in the submittal review process.
6. Upload the Submittal Register to the SLCDPU Project Central site or Procore.

C. Check Marked Specification Transmittal Procedures:

1. When submittal requirements require a "marked" copy of the specification, provide a copy of the specification marked as indicated below. Provide the following when transmitting the submittal:
    a. Provide a copy of the specification section(s) that specifies a marked copy of the specification. Include addendum updates and referenced specification sections, with addendum updates. Complete the following:
        1) Checkmark each paragraph to indicate submittal compliance with that specification requirement. Check marks (ü) shall denote full compliance with that paragraph as a whole.
        2) Mark paragraphs where deviations are proposed by underlining text that is the subject of the proposed deviation. Denoting each proposed deviation with a number in the margin to the right of the identified paragraph and provide a detailed written explanation for each numbered deviation. The remaining portions of the paragraph not underlined signify compliance with specified requirements.
        3) The Engineer is the final authority for determining acceptability of requested deviations.
    b. For equipment specifications, provide a copy of the control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the subject equipment. Complete the following:
        1) Mark drawings or diagrams to show specific changes necessary for the equipment proposed in the submittal.
        2) If no changes are required, mark the drawings or diagrams with "no changes required".

D. Provide a Certificate of Unit Responsibility assigning unit responsibility in accordance with the requirements of the specification Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with the Specifications.

E. Samples and Mock-ups:
   1. Submit samples and mock-ups in accordance with the Contract Documents. Package samples to facilitate review. Include the following with the Submittal Transmittal Form:
      a. Generic description of the sample
      b. Sample source
      c. Product name and name of manufacturer
      d. Compliance with recognized standards
      e. Submittal Number
      f. Availability and delivery time
      g. Specification Section
   2. Submit samples and mock-ups before installation. Where variation in color, pattern, texture or other characteristics are inherent in the material, submit four units to show variation range.
   3. Where samples are for selection of appearance characteristics from a range of standard choices, submit a full set of choices for the material or products.
   4. Maintain sets of approved samples and mock-ups at the Project Site, for quality comparisons throughout the course of construction.
   5. Demolish and remove all samples and mock-ups prior to substantial completion.

3.03 REVIEW PROCEDURE

A. General:
   1. Owner's Representative will review each submittal, indicate a REVIEW ACTION, and return to the Contractor.
   2. Returned submittals indicate one of the following REVIEW ACTIONS: NO EXEMPTIONS TAKEN, MAKE CORRECTIONS NOTED, AMEND AND RESUBMIT, or REJECTED – SEE REMARKS.

3.04 EFFECT OF REVIEW OF CONTRACTOR'S SUBMITTALS

A. General:
   1. Review of contract drawings, methods of work, or information regarding materials or equipment the Contractor proposes to provide, does not relieve the Contractor of responsibility for errors therein and is not regarded as an assumption of risks or liability by the Owner's Representative or the Owner, or by any officer or employee thereof, and the Contractor has no claim under the contract on account of the failure, or partial failure, of the method of work, material, or equipment reviewed. A mark of "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" means that the Owner has no objection to the Contractor, upon his own responsibility, using the plan or method of work proposed, or providing the materials or equipment proposed.

END OF SECTION

SUBMITTAL REGISTER

PROJECT TITLE:_____

LOCATION: _____ Job No. .

CONTRACTOR:

SCHEDULED ACTIVITY	SUBMITTAL ITEM No.	SPECIFICATION PARAGRAPH No.	DESCRIPTION OF MATERIAL	TYPE OF SUBMITTAL										REVIEW ACTION	CONTRACTOR NEED DATES			ENGINEER ACTION DATES		OTHER
				SAMPLES	SHOP DRAWINGS	PARTS LIST	PRODUCT DATA	DESIGN DATA	SPECIFICAITONS	CERTIFICATIONS	INSTRUCTIONS	O&M MANUAL	OTHER	REVIEW REQUIRED BY	SUBMITTAL DATE	APPROVAL NEEDED BY	MATERIAL NEEDED BY	DATE RECEIVED	ACTION CODE	

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SECTION 01 35 24

CONTRACTORS CERTIFICATION OF

COMPLIANCE TO SAFETY PLAN

PART 1 GENERAL

1.01 CONTRACTORS CERTIFICATION

A. The Contractor will certify that they will comply with the Safety and Protection Plan requirements of the City. A letter from the Contractor describing the hazards present on this project and their plan to mitigate those hazards is attached following this page.

END OF SECTION

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SECTION 01 35 43

ENVIRONMENTAL PROCEDURES

PART 1 GENERAL

1.01 SITE MAINTENANCE

A. The Contractor shall keep the work site clean and free from rubbish and debris. Materials and equipment shall be removed from the site when they are no longer necessary. Upon completion of the work and before final acceptance, the work site shall be cleared of equipment, unused materials, and rubbish to present a clean and neat appearance.

1.02 TEMPORARY DAMS

A. Except in time of emergency, earth dams are not acceptable at catch basin openings, local depressions, or elsewhere. Temporary dams of sand bags, asphaltic concrete, or other acceptable material will be permitted when necessary to protect the work, provided their use does not create a hazard or nuisance to the public. Such dams shall be removed from the site as soon as they are no longer necessary.

1.03 AIR POLLUTION CONTROL

A. The Contractor shall not discharge smoke, dust, and other contaminants into the atmosphere that violate the regulations of any legally constituted authority. He shall also abate dust nuisance by cleaning, sweeping, and sprinkling with water, or other means as necessary. The use of water, in amounts which result in mud on public streets, is not acceptable as a substitute for sweeping or other methods.

1.04 NOISE CONTROL

A. Between 7:30 p.m. and 7:00 a.m., noise from Contractor's operations shall not exceed limits established by applicable laws or regulations and in no event shall exceed 86 dBA at a distance of 50 feet from the noise source.

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SECTION 01 42 19

REFERENCE STANDARDS

PART 1 GENERAL

1.01 ABBREVIATOINS

A. Wherever used in the project manual, the following abbreviations will have the meanings listed:

Abbreviation	Meaning
AA	Aluminum Association Incorporated P.O. Box 753 Waldorf, MD 20604
AABC	Associated Air Balance Council 1518 K Street N.W. Washington, DC 20005
AAMA	American Architectural Manufacturers Association 1540 East Dundee Road, Suite 310 Palatine, IL 60067
AASHTO	American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, DC 20001
ABMA	American Bearing Manufacturers Association 1200 19th Street N.W., Suite 300 Washington, DC 20036
ACI	American Concrete Institute 22400 West Seven Mile Road P.O. Box 19150, Redford Station Detroit, MI 48219
AEIC	Association of Edison Illuminating Companies 600 North 18th Street P.O. Box 2641 Birmingham, AL 35291
AGA	American Gas Association ATTN: Records 1515 Wilson Boulevard Arlington, VA 22209
AGMA	American Gear Manufacturer's Association, Inc. 1500 King Street, Suite 201 Alexandria, VA 22314
AHA	American Hardboard Association 1210 West Northwest Highway Palatine, IL 60067
AISC	American Institute of Steel Construction One East Wacker Drive, Suite 3100 Chicago, IL 60601

Abbreviation	Meaning
AISI	American Iron and Steel Institute 1101 Seventeenth Street, NW, Suite 1300 Washington, DC 20036
AITC	American Institute of Timber Construction 7012 South Revere Parkway, Suite 140 Englewood, CO 80112
ALSC	American Lumber Standard Committee P.O. Box 210 Germantown, MD 20875
AMCA	Air Movement and Control Association, Inc. 30 West University Drive Arlington Heights, IL 60004
ANSI	American National Standards Institute 11 West 42nd Street, 13th Floor New York, NY 10036
APA	American Plywood Association 7011 South 19th Street Tacoma, WA 98466
API	American Petroleum Institute 1220 "L" Street N.W. Washington, DC 20005
ARI	Air-Conditioning and Refrigeration Institute 4301 North Fairfax Drive, Suite 425 Arlington, VA 22203
ASCE	American Society of Civil Engineers United Engineering Center 345 East 47th Street New York, NY 10017
ASCII	American Standard Code for Information Interchange United States of America Standards Institute 10 East 40th Street New York, NY 10016
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. 1791 Tullie Circle, NE Atlanta, GA 30329
ASME	American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, PA 19428

Abbreviation	Meaning
AWPA	American Wood-Preservers' Association 9549 Old Fredrick Road Ellicott City, MD 21042
	or P.O. Box 286 Woodstock, MD 21163-0286
AWS	American Welding Society 550 NW LeJeune Road P.O. Box 351040 Miami, FL 33135
AWWA	American Water Works Association 6666 West Quincy Avenue Denver, CO 80235
BOCA	Building Officials and Code Administrators, International, Inc. 4051 West Flossmoor Road Country Club Hills, IL 60478
CBM	Certified Ballast Manufacturers 2120 Keith Building Cleveland, OH 44115
CMAA	Crane Manufacturers Association of America, Inc. (Formerly called: Overhead Electrical Crane Institute) (OECI) 8720 Red Oak Boulevard, Suite 201 Charlotte, NC 28217
CRSI	Concrete Reinforcing Steel Institute 933 N Plum Grove Road Schaumburg, IL 60173
DEMA	Diesel Engine Manufacturer's Association 30200 Detroit Road Cleveland, OH 44145
DHI	Door and Hardware Institute 14170 Newbrook Drive Chantilly, VA 22021
EIA	Electronic Industries Association Order from: Global Engineering Documents 18201 McDurmott West Irvine, CA 92714
EJMA	Expansion Joint Manufacturers Association 25 North Broadway Tarrytown, NY 10591
FEDSPEC	Federal Specifications General Services Administration Specification and Consumer Information Distribution Branch Washington Navy Yard, Bldg. 197 Washington, DC 20407

Abbreviation	Meaning
FEDSTDS (see FEDSPECS)	Federal Standards
FM	Factory Mutual Engineering and Research Corporation 1151 Boston-Providence Turnpike P.O. Box 9102 Norwood, MA 02062
HEI	Heat Exchange Institute 1300 Sumner Avenue Cleveland, OH 44115
HI	Hydraulic Institute 9 Sylvan Way, Suite 180 Parsippany, NJ 07054
HPVA	Hardwood Plywood & Veneer Association 1825 Michael Faraday Drive P.O. Box 2789 Reston, VA 22090-2789
IAPMO	International Association of Plumbing and Mechanical Officials 20001 Walnut Drive S Walnut, CA 91789
IBC	International Building Code 200 Massachusetts Avenue Washington, DC
ICBO	International Conference of Building Officials 5360 Workman Mill Road Whittier, CA 90601
ICEA	Insulated Cable Engineers Association P.O. Box 440 South Yarmouth, MA 02664
IEEE	Institute of Electrical and Electronics Engineers 445 Hoes Lane P.O. Box 1331 Piscataway, NJ 08855
IES	Illuminating Engineering Society of North America 120 Wall Street New York, NY 10017
ISA	Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709
JIC	Joint Industrial Council 7901 West Park Drive McLean, VA 22101
MFMA	Metal Framing Manufacturers Association 401 N. Michigan Avenue Chicago, IL 60611

Abbreviation	Meaning
MSS	Manufacturers Standardization Society of the Valve & Fittings Industry, Inc. 127 Park Street, N.E. Vienna, VA 22180
NAAMM	National Association of Architectural Metal Manufacturers 11 South La Salle Street, Suite 1400 Chicago, IL 60603
NACE	National Association of Corrosion Engineers 1440 South Creek Drive Houston, TX 77084
NBC	National Building Code Published by BOCA
NEC	National Electric Code National Fire Protection Association One Batterymarch Park P.O. Box 9101 Quincy, MA 02269
NELMA	Northeastern Lumber Manufacturers Association, Inc. P.O. Box 87A Cumberland Center, ME 04021
NEMA	National Electrical Manufacturer's Association 2101 L Street, NW, Suite 300 Washington, DC 20037
NESC	National Electric Safety Code American National Standards Institute 1430 Broadway New York, NY 10018
NFOR	National Forest Products Association (Formerly National Lumber Manufacturer's Association) 1111 19 Street NW, Suite 700 Washington, DC 20036
NFPA	National Fire Protection Association One Batterymarch Park P.O. Box 9101 Quincy, MA 02269
NHLA	National Hardwood Lumber Association 6830 Raleigh LaGrange P.O. Box 34518 Memphis, TN 38184-0518
NSF	National Sanitation Foundation 3475 Plymouth Road P.O. Box 130140 Ann Arbor, MI 48113

Abbreviation	Meaning
OSHA	Occupational Safety and Health Act U.S. Department of Labor Occupational and Health Administration San Francisco Regional Office 450 Golden Gate Avenue, Box 36017 San Francisco, CA 94102
PCI	Precast/Prestressed Concrete Institute 175 West Jackson Blvd., Suite 1859 Chicago, IL 60604
PPIC	The Plumbing & Piping Industry Council, Inc. 510 Shatto Place, Suite 402 Los Angeles, CA 90020
RMA	Rubber Manufacturers Association 1400 K Street NW, Suite 900 Washington, DC 20005
SAE	Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096
SAMA	Scientific Apparatus Makers Association One Thomas Circle Washington, DC 20005
SBC	Standard Building Code Published by SBCCI
SDI	Steel Door Institute 30200 Detroit Road Cleveland, OH 44145
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc. P.O. Box 221230 Chantilly, VA 22021
SPI	Society of the Plastics Industry, Inc. 1275 K Street NW, Suite 400 Washington, DC 20005
SSPC	Society for Protective Coatings 40 24th Street, 6th Floor Pittsburgh, PA 15222
SSPWC	Standard Specifications for Public Works Construction Building News, Inc. 3055 Overland Avenue Los Angeles, CA 90034
TEMA	Tubular Exchanger Manufacturer's Association 25 North Broadway Tarrytown, NY 10591
TPI	Truss Plate Institute 583 D'Onofrio Drive, Suite 200 Madison, WI 53719

Abbreviation	Meaning
UBC	Uniform Building Code Published by ICBO
UL	Underwriters Laboratories Inc. 333 Pfingsten Road Northbrook, IL 60062
UMC	Uniform Mechanical Code Published by ICBO
UPC	Uniform Plumbing Code Published by IAPMO

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SECTION 01 45 00
QUALITY CONTROL

This specification changes a portion of APWA Standard Specification Section 01 45 00. All other provisions of the Section remain in full force and effect.

Add the following Article to Part 1.

1.8 QUALITY CONTROL PROGRAM

A. Quality Control Program: Provide a quality control program which includes procedures and organization so equipment, workmanship, fabrication, construction, operations, and inspections comply with the Contract Documents.

B. Quality Control Program Manager Qualifications:

1. Not CONTRACTOR's work or site superintendent.
2. Quality control experience with projects of similar type and magnitude.
3. Authorized as CONTRACTOR's representative for all quality control and quality assurance matters.

C. Quality Control Program Manager Responsibilities:

1. Manage and supervise quality control plan and quality control surveillance personnel.
2. Verify that testing procedures comply with contract requirements.
3. Verify that facilities and testing equipment are available and comply with testing standards.
4. Check test instrument calibration data against certified standards.
5. Verify that recording forms, including all the documentation requirements, have been prepared.
6. Prepare copies of each test result with all necessary data recorded and with documentation and computations compiled.
7. Provide more testing, if, in ENGINEER's opinion, work is not being adequately controlled.
8. Immediately report any non-compliance of materials and mixes to ENGINEER and CONTRACTOR.
9. When an out-of-tolerance condition exists, perform additional control testing until tolerance is attained.
10. Correlate CONTRACTOR's assurance testing program (APWA Section 01 43 00) with ENGINEER's acceptance testing program (APWA Section 01 45 00).

END OF SECTION

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SECTION 01 45 20

EQUIPMENT AND SYSTEM PERFORMANCE AND OPERATIONAL TESTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for the Contractor's performance in documenting testing work required under this contract. In addition, this section contains requirements the for the Contractor's performance during installed performance testing of all mechanical, electrical, instrumentation, and HVAC equipment and systems, including structures for watertight construction, provided under this contract. This section supplements but does not supersede specific testing requirements found elsewhere in this project manual.

1.02 QUALITY ASSURANCE

A. Contractor's Quality Assurance Manager:

1. The Contractor shall appoint an operations engineer or equally qualified operations specialist as Quality Assurance Manager to manage, coordinate, and supervise the Contractor's quality assurance program. The Quality Assurance Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the startup commissioning of mechanical, electrical, instrumentation, HVAC, and piping systems. Operations engineers shall be graduates from a minimum 4-year course in mechanical or civil engineering. Operations specialists shall have equivalent experience in plant operation and maintenance. The quality assurance program shall include:
    a. A testing plan setting forth the sequence in which all testing work required under this project manual will be implemented.
    b. A documentation program to record the results of all equipment and system tests.
    c. An installed performance testing program for all mechanical, electrical, instrumentation, and HVAC equipment and systems installed under this contract.
    d. A calibration program for all instruments, meters, monitors, gages, and thermometers installed under this contract.
    e. A calibration program for all instruments, gages, meters, and thermometers used for determining the performance of equipment and systems installed under this contract.
    f. A testing schedule conforming to the requirements specified in paragraph 2.02 Testing Schedule.
2. For the purposes of this section, a system shall include all items of equipment, devices and appurtenances connected in such a fashion as their operation or function complements, protects or controls the operation or function of the others. The Quality Assurance Manager shall coordinate the activities of all subcontractors and suppliers to implement the requirements of this section.

B. Calibration:

1. All test equipment (gages, meters, thermometers, analysis instruments, and other equipment) used for calibrating or verifying the performance of equipment installed under this contract shall be calibrated to within plus or minus 2 percent of actual value at full scale. Test equipment employed for individual test runs shall be selected so that expected values as indicated by the detailed performance specifications will fall between 60 and 85 percent of full scale. Pressure gages shall be calibrated in accordance with ANSI/ASME B40.1. Thermometers shall be calibrated in accordance with ASTM E77 and shall be furnished with a certified calibration curve.
2. Liquid flow meters, including all open channel flow meters and all meters installed in pipelines with diameters greater than 2 inches shall be calibrated in situ using either the total count or dye dilution methods. Flow meter calibration work shall be performed by individuals skilled in the techniques to be employed. Calibration tests for flow metering systems shall be performed over a range of not less than 10 percent to at least 75 percent of system full scale. At least five confirmed valid data points shall be obtained within this range. Confirmed data points shall be validated by not less than three test runs with results which agree within plus or minus 2 percent.

C. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of issue to the Contractor to develop their Guaranteed Maximum Price (GMP). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASME B40.1	Gauges Pressure Indicating Dial Type—Elastic Element
ASTM E77	Method for Verification and Calibration of Liquid-in-Glass Thermometers
Dye Dilution Calibration Method	
	Flow Measurement in Open Channels and Closed Conduits, Vol 1, U.S. Department of Commerce, National Bureau of Standards, pg. 361
	Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter 16, Measurement of Discharge Using Tracers

1.03 SUBMITTALS

A. Submittal material, to be submitted in accordance with Section 01 33 00, shall consist of the following:
   1. A complete description of the Contractor's plan for documenting the results from the test program in conformance with the requirements of paragraph 2.02 Documentation Plans, including:
      a. Proposed plan for documenting the calibration of all test instruments.
      b. Proposed plan for calibration of all instrument systems, including flow meters and all temperature, pressure, weight, and analysis systems.
      c. Sample forms for documenting the results of field pressure and performance tests.
   2. The credentials and certification of the testing laboratory proposed by the Contractor for calibration of all test equipment.
   3. Preoperational check-out procedures, reviewed and approved by the respective equipment manufacturers.
   4. Detailed testing plans, setting forth step-by-step descriptions of the procedures proposed by the Contractor for the systematic testing of all equipment and systems installed under this contract.
   5. A schedule and subsequent updates, presenting the Contractor's plan for testing the equipment and systems installed under this contract.
   6. A schedule establishing the expected time period (calendar dates) when the Contractor plans to commence operational testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.
   7. A summary of the Quality Assurance Manager's qualifications, showing conformance to paragraph 1.02 Contractor’s Quality Assurance Manager requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall prepare test plans and documentation plans as specified in the following paragraphs. The Construction Manager will not witness any test work for the purpose of acceptance until all test documentation and calibration plans and the specified system or equipment test plans have been submitted and accepted.

2.02 DOCUMENTATION

A. Documentation Plans:
   1. The Contractor shall develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.

2. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the Construction manager's witness and the Contractor's quality assurance manager. A separate file shall be established for each system and item of equipment. These files shall include the following information as a minimum:
    a. Metallurgical tests
    b. Factory performance tests
    c. Accelerometer recordings made during shipment
    d. Field calibration tests[1]
    e. Field pressure tests[1]
    f. Field performance tests[1]
    g. Field operational tests[1]
3. Section 01 99 90 contains samples showing the format and level of detail required for the documentation forms. The Contractor is advised that these are samples only and are not specific to this project nor to any item of equipment or system to be installed under this contract. The Contractor shall develop test documentation forms specific to each item of equipment and system installed under this contract. Once the Construction Manager has reviewed and taken no exception to the forms proposed by the Contractor, the Contractor shall produce sufficient forms, at his expense, to provide documentation of all testing work to be conducted as a part of this contract.

B. Test Plans:
1. The Contractor shall develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or tag number each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Test plans shall also be specific as to support systems required to complete the test work, temporary systems required during the test work, subcontractors' and manufacturers' representatives to be present and expected test duration. As a minimum, the test plans shall include the following features:
    a. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
    b. Calibration of all analysis instruments and control sensors.
    c. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in the project manual.
    d. System tests designed to duplicate, as closely as possible, operating conditions described in the project manual.
2. Test plans shall contain a complete description of the procedures to be employed to achieve the desired test environment.

[1]Each of these tests is required even though not specifically noted in detailed specification section.

3. The Contractor shall have submitted all test plans required for the systematic field performance and operational tests for all equipment and systems installed under this contract. Once the Construction Manager has reviewed and taken no exception to the Contractor's test plans, the Contractor shall reproduce the plans in sufficient number for the Contractor's purposes and copies for delivery to the Construction Manager. No test work shall begin until the Contractor has delivered the specified number of final test plans to the Construction Manager.

C. Testing Schedule:

1. The Contractor shall produce a testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be in bar chart form, plotted against calendar time, shall detail the equipment and systems to be tested, and shall be coordinated with the Contractor's construction schedule specified in Section 01 32 17. The schedule shall show the contemplated start date, duration of the test and completion of each test. The test schedule shall be submitted no later than 4 weeks in advance of the date testing is to begin. The Construction Manager will not witness any testing work for the purpose of acceptance until the Contractor has submitted a schedule to which the Construction Manager takes no exception. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of this project manual.

2.03 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

A. Each item of mechanical, electrical, instrumentation, and HVAC equipment installed under this contract shall be tested to demonstrate compliance with the performance requirements of this project manual. Each electrical, instrumentation, mechanical, piping, and HVAC system installed or modified under this contract shall be tested in accordance with the requirements of this project manual.

2.04 OPERATIONAL TESTS

A. Once all equipment and systems have been tested individually, the Contractor shall fill all systems except wastewater, scum sludge and other wastewater derived systems with the intended process fluids. Wastewater-derived process systems shall be filled with water. After filling operations have been completed, the Contractor shall operate all systems for a continuous period of not less than 30 days, simulating actual operating conditions to the greatest extent possible. The Contractor shall install temporary connections, bulkheads and make other provisions to recirculate process fluids or otherwise simulate anticipated operating conditions. During the operational testing period, the Contractor's Quality Assurance Manager and testing team shall monitor the characteristics of each machine and system and report any unusual conditions to the Construction Manager.

2.05 PRODUCT DATA

A. Product data, to be provided in accordance with Section 01 33 00, shall be the original and three copies of all records produced during the testing program.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor's quality control manager shall organize teams made up of qualified representatives of equipment suppliers, subcontractors, the Contractor's independent testing laboratory, and others, as appropriate, to efficiently and expeditiously calibrate and test the equipment and systems installed and constructed under this contract. The objective of the testing program shall be to demonstrate, to the Construction Manager's complete satisfaction, that the structures, systems, and equipment constructed and installed under this contract meet all performance requirements and the facility is ready for the commissioning process to commence. In addition, the testing program shall produce baseline operating conditions for the Owner to use in a preventive maintenance program.

3.02 CALIBRATION OF FIXED INSTRUMENTS

A. Calibration of analysis instruments, sensors, gages, and meters installed under this contract shall proceed on a system-by-system basis. No equipment or system performance acceptance tests shall be performed until instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by the Construction Manager.

B. All analysis instruments, sensors, gages, and meters used for performance testing shall be subject to recalibration to confirm accuracy after completion, but prior to acceptance of each performance test. All analysis instruments, sensors, gages, and meters installed under this contract shall be subject to recalibration as a condition precedent to commissioning under the provisions of Section 01 91 00.

3.03 PERFORMANCE TESTS

A. General:
   1. Performance tests shall consist of the following:
      a. Pressure and/or leakage tests.
      b. Electrical testing as specified in Division 26.
      c. Wiring and piping, individual component, loop, loop commissioning and tuning testing as described in Division 40.
      d. Preoperational checkout for all mechanical and HVAC equipment. Preoperational check-out procedures shall be reviewed and approved by the respective equipment manufacturers.
      e. Initial operation tests of all mechanical, electrical, HVAC, and instrumentation equipment and systems to demonstrate compliance with the performance requirements of this project manual.
   2. In general, performance tests for any individual system shall be performed in the order listed above. The order may be altered only on the specific written authorization of the Construction Manager after receipt of a written request, complete with justification of the need for the change in sequence.

B. Pressure And Leakage Tests:
   1. Pressure and leakage tests shall be conducted in accordance with applicable portions of Divisions 3 and 40. All acceptance tests shall be witnessed by the Construction Manager. Evidence of successful completion of the pressure and leakage tests shall be the Construction Manager's signature on the test forms prepared by the Contractor.

C. Functional Checkout:
   1. Prior to energization (in the case of electrical systems and equipment), all circuits shall be rung out and tested for continuity and shielding in accordance with the procedures required in Division 26.

D. Component Calibration And Loop Testing:
   1. Prior to energization (in the case of instrumentation system and equipment), all loops and associated instruments shall be calibrated and tested in accordance with the procedures required in Division 40.

E. Electrical Resistance:
   1. Electrical resistance testing shall be in accordance with Division 26.

F. Preoperational Tests:
   1. Preoperational tests shall include the following:
      a. Alignment of equipment using reverse dial indicator method.
      b. Pre-operation lubrication.
      c. Tests per the manufacturers' recommendations for prestart preparation and preoperational check-out procedures.

G. Functional Tests:

1. General: Once all affected equipment has been subjected to the required preoperational check-out procedures and the Construction Manager has witnessed and has not found deficiencies in that portion of the work, individual items of equipment and systems may be started and operated under simulated operating conditions to determine as nearly as possible whether the equipment and systems meet the requirements of these specifications. If available, plant effluent may be employed for the testing of all liquid systems except gaseous, oil, or chemical systems. If not available, potable water shall be employed as the test medium. Test media for these systems shall either be the intended fluid or a compatible substitute. The equipment shall be operated a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls. When testing requires the availability of auxiliary systems such as looped piping, electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, the Contractor shall provide acceptable substitute sources, capable of meeting the requirements of the machine, device, or system at no additional cost to the Owner. Disposal methods for test media shall be subject to review by the Construction Manager. During the functional test period, the Contractor shall obtain baseline operating data on all equipment with motors greater than 1 horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for the Owner to enter in a preventive maintenance system.
    a. Test results shall be within the tolerances set forth in the detailed specification sections of this project manual. If no tolerances have been specified, test results shall conform to tolerances established by recognized industry practice. Where, in the case of an otherwise satisfactory functional test, any doubt, dispute, or difference should arise between the Construction Manager and the Contractor regarding the test results or the methods or equipment used in the performance of such test, then the Construction Manager may order the test to be repeated. If the repeat test, using such modified methods or equipment as the Construction Manager may require, confirms the previous test, then all costs in connection with the repeat test will be paid by the Owner. Otherwise, the costs shall be borne by the Contractor. Where the results of any functional test fail to comply with the contract requirements for such test, then such repeat tests as may be necessary to achieve the contract requirements shall be made by the Contractor at his expense.
    b. The Contractor shall provide, at no expense to the Owner, all power, fuel, compressed air supplies, water, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities are not complete and operable at the time of functional tests, and all other items and work required to complete the functional tests. Temporary facilities shall be maintained until permanent systems are in service.
2. Retesting: If under test, any portion of the work should fail to fulfill the contract requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the work as are affected thereby, shall, unless otherwise directed by the Construction Manager, be repeated within reasonable time and in accordance with the specified conditions. The Contractor shall pay to the Owner all reasonable expenses incurred by the Owner, including the costs of the Construction Manager, as a result of repeating such tests.

3. Post-test Inspection: Once functional testing has been completed, all machines shall be rechecked for proper alignment and realigned, as required. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the Construction Manager. All machines or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled and inspected. Any defects found during the course of the inspection shall be repaired or the specific part or entire equipment item shall be replaced to the complete satisfaction of the Construction Manager at no cost to the Owner.

3.04 OPERATIONAL TESTS

A. The Contractor shall provide system operation testing. After completion of all performance testing and certification by the Construction Manager that all equipment complies with the requirements of the specifications, the Contractor shall fill all process units and process systems, except those employing domestic water, oil, air, or chemicals, with plant effluent water. All domestic water, oil, air, and chemical systems shall be filled with the specified fluid.

B. Upon completion of the filling operations, the Contractor shall circulate water through the completed facility for a period of not less than 48 hours, during which all parts of the system shall be operated as a complete facility at various loading conditions, as directed by the Construction Manager. The operational testing period shall commence after this initial period of variable operation. Should the operational testing period be halted for any reason related to the facilities constructed or the equipment furnished under this contract, or the Contractor's temporary testing systems, the operational testing program shall be repeated until the specified continuous period has been accomplished without interruption. All process units shall be brought to full operating conditions, including temperature, pressure, and flow.

C. As-built documents specified in Section 01 78 39 of facilities involved shall be accepted and ready for turnover to the Owner at the time of operational testing.

END OF SECTION

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SECTION 01 45 23

TESTING AND INSPECTION SERVICES

PART 1 GENERAL

1.01 SUMMARY

A. GENERAL REQUIREMENTS: Comply with the testing and inspection specified in this Section and elsewhere in the Construction Documents. For the purpose of this Section, all references made herein to Testing Agency or Special Inspector or Geotechnical Consulting Firm shall be referred to as those tests or inspections which will be conducted by an inspector provided by the Owner.

1. The Owner or registered design professional in responsible charge acting as the Owner's agent will select and employ an independent Testing Agency to conduct the tests and inspections in accordance with applicable standard methods of American Society for Testing and Materials (ASTM) as a requirement of the building permit. The Owner may require other special inspection services to inspect and verify the Work installed is in accordance with the Construction Documents and construction industry standards.

1.02 DEFINITIONS

A. Special Inspector – A qualified individual employed or retained by an approved agency and approved by SLCDPU as having the competency necessary to inspect a particular type of construction requiring special inspection.

B. Testing Agency - firm responsible for performing specific inspections and/or tests as part of the Special Inspection program.

1.03 QUALITY ASSURANCE

A. QUALIFICATIONS: The inspector for all Work as hereinafter specified, except for geotechnical inspections, waterproofing and roofing, shall be a registered Special Inspector employed by an approved inspection and/or Testing Agency. All inspection personnel used on this Project are subject to being disapproved from the Project at the discretion of the Owner.

1. The Special Inspector shall have the required technical knowledge and experience for the product or construction element being installed.
2. Geotechnical Inspection will be performed by a licensed Geotechnical Consulting Firm.

1.04 DUTIES OF OWNER'S TESTING AGENCY

A. GENERAL: The Owner's Testing Agency will conduct testing and inspection services, interpret them, and evaluate the results for compliance with the building permit, the site development permit, and the Construction Documents; agency will report findings to the Owner, Contractor, and Owner's Resident Project Representative (RPR). Testing and inspection services shall be in accordance with applicable standard methods of ASTM or other standards specified by SLCDPU, the Construction Documents, and construction industry standards. The Testing Agency will reasonably support overtime, second shift, and out-of-area activity if requested by the Contractor and approved at the Owner's sole discretion.

B. TESTING AND INSPECTION: Materials to be tested are specified by the building permit and as required by the Construction Documents, as directed by Owner, or required by Owner's RPR. Quantities and extent of tests and inspections shall be as specified and/or required by the Owner's RPR.

C. NON-CONFORMING WORK: The Owner's Inspector shall document and immediately notify the Contractor and Owner of any Work found defective or not in accordance with the requirements of the Construction Documents. Non-conforming Work shall be corrected.

D. The Owner's inspectors are not authorized to do the following:
   1. Release, revoke, alter or enlarge on requirements of Construction Documents.
   2. Approve or accept any portion of the Work.
   3. Perform any duties of the Contractor.
   4. Stop Work.

1.05 COSTS

A. The Owner's Testing Agency and Special Inspector costs for initial testing and inspection as specified in the Construction Documents will be paid for by the Owner or registered design professional in responsible charge acting as the Owner's agent. Initial tests and inspections are defined as those required to complete the first tests and inspections specified. Costs for subsequent re-testing and re-inspection of items found not to be in compliance with Construction Documents shall be borne by the Contractor.

B. Additional tests and inspections not herein specified, but requested by the Owner, shall be paid for by the Owner. However, if the results of such tests or inspections are found to be not in compliance with Construction Documents, the Contractor will be back charged for all costs for initial testing as well as re-testing, re-inspection and Owner's Consultants services.

C. Costs for additional tests or inspections required because of Contractor changes to reviewed and accepted products or materials provided, or source, or supply shall be borne by the Contractor.

D. Costs for any Work which is required to correct any deficiencies shall be borne by the Contractor.

E. Costs of any testing which is required solely for the convenience of Contractor in its scheduling and performance of the Work shall be borne by the Contractor.

F. Costs for verification testing of Work done without prior notice, with improper supervision, or contrary to construction practice shall be borne by the Contractor.

G. Costs for testing of materials for which fabrication and mill reports are required but not furnished shall be borne by the Contractor.

H. The cost, if any, of providing access for inspections and tests shall be considered part of the normal expense of conducting business and therefore non-reimbursable.

I. In those instances where inspector(s) arrive at the agreed-upon location, at the agreed upon date and time, and find articles to be inspected are not ready for inspection, the inspector(s) shall return to their home office and all expenses incurred shall be borne by the Contractor.

1.06 TESTS AND INSPECTION REPORTS

A. Copies of Owner and Contractor test and inspection reports shall be distributed at weekly intervals. Such reports shall include all tests made, regardless of whether such tests indicate that the material is satisfactory or unsatisfactory; a final report should be submitted documenting corrective work done on of any unsatisfactory material and or work identified in the testing or inspection reports. Samples taken, but not tested, shall also be reported. Records of special sampling operations that are required shall also be reported. Test and inspection reports shall be distributed as follows:
   1. Owner
   2. Owner's RPR
   3. Contractor
   4. Structural Engineer of Record

B. A report shall be prepared for each inspection and test and shall include:
   1. Date issued.
   2. Project title and number.
   3. Name and signature of inspector.
   4. Date of inspection or sampling and test.
   5. Record of temperature and weather.
   6. Identification of product and Specification Section.
   7. Location in Project.
   8. Type of inspection or test.
   9. Results of inspections and tests, and observations regarding compliance with Laws and Regulations, and standards.

1.07 CONTRACTOR'S RESPONSIBILITIES

A. COORDINATION: It is the Contractor's responsibility to initiate, coordinate, and conform to the required tests and inspections. Inspection of the Work by the Owner's Special Inspectors and/or Testing Agency shall not relieve the Contractor from responsibility for compliance with the Construction Documents requirements. Owner's Special Inspectors and/or Testing Agency and Owner shall have authority to reject Work whenever the provisions of the Construction Documents are not being complied with, and the Contractor shall instruct his employees accordingly.

B. ACCESS FOR THE PURPOSE OF INSPECTION: Ensure the Owner's Special Inspectors and/or Testing Agency have free access to all parts of the Work and to the shops where the Work is in preparation; are provided proper facilities and safe access for such inspection; and are reasonably furnished access, equipment, tools, samples, certifications, test reports, design mixes, storage, and assistance as requested by the Owner's Inspector.

C. STORAGE FACILITIES: Furnish adequate storage facilities as approved by the Owner for the sole use of the Owner's Testing Agency for safe storage and curing of such specimens which must remain on the site prior to transport to the laboratory.

D. DATA: Furnish records, Contract Drawings and shop drawings, certificates, approved Change Orders, and similar data as required by Owner's Inspectors to perform their work to assure compliance with the Construction Documents.

E. NOTICE: Furnish notice to Owner and coordinate with Owner's Inspectors a minimum of five (5) working days in advance of all required tests and a minimum of forty-eight (48) hours in advance of all required inspections, unless otherwise specified.

F. NON-CONFORMING WORK: Remove and replace Non-conforming Work at no additional cost to the Owner prior to Final Completion. Where Non-conforming Work requires design modifications, such re-design shall be performed by the Engineer of Record and costs shall be borne by the Contractor.

G. CANCELLATIONS: Contractor shall give sufficient advance notice to Owner and Inspectors to allow rescheduling of their work load in the event of cancellation or time extension of any scheduled test or inspection

1.08 TEST FAILURES

A. GENERAL: The Owner may require re-test of a sampled material when a sample or procedure has failed to pass the required tests. In the event any test or inspection indicates failure of a material or procedure to meet requirements of Construction Documents, all costs for re-testing or re-inspection shall be borne by the Contractor. The Contractor may opt to replace the imperfect Work, equipment or material in lieu of performing the tests.

1.09 REPORT TEST FAILURES

A. GENERAL: Immediately upon determination of a test failure, the Owner's Inspector shall notify the Owner and Contractor. By the end of the following day the Owner's Inspector shall send written test results to those named on the distribution list.

B. Contractor shall similarly report test failures to Owner resulting from work of testing agencies provided by the Contractor.

PART 2 - NOT USED

PART 3 - EXECUTION

A. Contractor shall complete field testing in accordance with the minimum requirements indicated in the following schedule and throughout the Contract Documents. Additional source material testing shall be complete as necessary to establish the basis of field tests. The frequency of testing in this schedule lists the minimum number of tests to be requested and completed per quantity of work completed by the Contractor and should be verified in the individual Specifications sections. See the Statement of Special Inspections in the General Structural Notes for additional information and requirements.

B. FILL
   1. SUBGRADE PREPARATION AND COMPACTION: Verify depth of scarification, moisture content within optimal limits for compaction, and degree of compaction specified in Section 31 23 00. Frequency of testing shall generally conform to 25 foot maximum spacing for strip footings, each isolated pad footing, every 900 square feet for slabs and mat foundations, or as directed by the Resident Project Representative in light of actual geometry and conditions extent.
   2. STRUCTURE FILL: Verify material provided, lift thickness, and compaction density. Frequency of sampling and testing shall be the same as for Subgrade Preparation and Compaction.
   3. STRUCTURE BACKFILL: Verify material provided, lift thickness, and compaction density. Frequency of sampling and testing shall be as directed by the Resident Project Representative but not less than every 2 feet vertical (lifts) and every 1600 square feet of filled area.
   4. PIPE TRENCH BACKFILL: Verify material provided, lift thickness, and compaction density. Frequency of sampling and testing for Bedding, pipe zone, and trench back fill shall be at performed intervals no greater than 500 feet. Testing at minimum shall be performed at the spring line on both sides of the pipe and at 12-inches above the crown of the pipe.
   5. OTHER FILL MATERIALS: Verify material used, lift thickness, and compaction density. Frequency of sampling and testing shall be as directed by the Resident Project Representative/Construction Manager.

C. CONCRETE REINFORCING
   1. Provide Special Inspection for all structural reinforcing in concrete and masonry.
   2. Provide Special Inspection for mechanical reinforcing connectors and splicing systems as required by that product's ICBO Evaluation Report, or equivalent.

D. CAST-IN-PLACE CONCRETE
   1. Sample the first daily truck load of ready mixed concrete and every 50 cubic yards thereafter, complying with ASTMC 172.
   2. Perform one slump test for the first daily truck load of ready mixed concrete and every 50 cubic yards thereafter or as requested by Resident Project Representative/Construction Manager if consistency is in question, complying with ASTM C143.

3. Perform one air content test for each set of compressive strength specimens, complying with ASTM C 31.
4. Fabricate compressive strength specimens, complying with ASTM C 39.
5. Make one set of 6 of compressive strength specimens for each day of structural concrete placing or each 150 cubic yards or fraction thereof for each class of concrete.
6. Test two specimens after curing 7 days, two specimens after curing 28 days, and retain two specimens for later testing if required.
7. Comply with ACI 350 Section 5.6 (ACI 318 for non-water retaining structures) for evaluation and acceptance of concrete.

E. ANCHOR BOLTS AND ANCHORS

1. SPECIAL INSPECTIONS: Provide Special Inspection for wedge anchors, undercut anchors, adhesive anchors, epoxy anchors, and all other anchoring systems installed in hardened concrete and masonry as required by that product's ICBO Evaluation Report, or equivalent.
2. SITE INSPECTION OF STRUCTURAL ANCHOR BOLTS: Visually inspect all structural anchor bolts for grade, diameter, embedment, geometry or type ("J" bolt or hex-head), quantity and general location. Contractor shall assume all responsibility for detailed dimensions locating each individual bolt, each bolt group in total, and locations of bolts within each group (template).

F. ROUGH CARPENTRY

1. CONVENTIONAL FRAMING WITH SAWN LUMBER: Special Inspector visually inspect for size and grade of sawn lumber bearing wall elements, joists, rafters, and beams. Visually inspect for adequate bearing on supporting elements.
2. ENGINEERED AND MANUFACTURED WOOD JOISTS, BEAMS AND POSTS: Special Inspector visually inspect for size, type, and manufacturer's product grade for all elements using engineered and manufactured wood including glu-laminated members. Verify tension rated lamination of glu-laminated beams is properly oriented. Visually inspect for adequate bearing on supporting elements.
3. ENGINEERED WOOD TRUSSES: Special Inspector visually inspect against reviewed and accepted manufacturer's shop drawings, including general shape, chord and web sizes, bridging and bracing, and adequate bearing.
4. ROOF AND WALL SHEATHING: Special Inspector visually inspect for specified thickness and plies, Index, APA rating, strength axis across supporting members, staggered layout on roofs and floors, blocking or clips, edge nailing and field nailing.
5. CONNECTORS: Special Inspector verify bolted and nailed connections conform to specifications. In particular, visually inspect "gun nails" for conformance to specified common nail diameters and lengths. Inspect cold-formed steel framing connectors, rafter/truss ties, straps and seismic hold-downs according to ICBO Evaluation Report descriptions, controlling Code or specified standard. Inspect split ring connectors and their bolting.

END OF SECTION

SECTION 01 51 00

TEMPORARY UTILITIES

PART 1 GENERAL

1.01 OFFICE

A. The Contractor shall maintain a suitable office at the site of the work.

1.02 POWER

A. The Contractor shall provide power for construction at the plant site. He shall make arrangements with the electrical utility and with the Owner for power takeoff points, voltage and phasing requirements, transformers and metering and shall pay the costs and fees arising therefrom. The Contractor shall provide the special connections required for his work.

B. Contractor shall arrange for, pay for, install, protect, and maintain piping for all construction water and facilities. Secure written permission from the Owner for each connection and use of the Owner's water system. Meet the Owner's specified requirements for use. The fire hydrants at the plant are fed from the Filter Backwash Tank. Obtain permission from the Owner prior to using any water from any onsite fire hydrant. Notify the fire department before obtaining water from any fire hydrants located outside of the plant boundaries. Use only special hydrant-opening wrenches to open hydrants. Makes certain hydrant valve is fully open, since cracking the valve causes damage to the hydrant. Notify the City and the Fire Department immediately of any hydrant damage. Hydrants shall be completely accessible to fire department at all times.

1.03 TELEPHONE

A. The Contractor shall provide telephone service at his construction site office. Radio-telephone service is not acceptable as a substitute for telephone service.

1.04 SANITARY FACILITIES

A. The Contractor shall provide toilet and washup facilities for his work force at the site of work. The facilities shall comply with applicable laws, ordinances, and regulations pertaining to the public health and sanitation of dwellings and camps.

END OF SECTION

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SECTION 01 52 00

CONSTRUCTION FACILITIES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies field office equipment, and services to be provided for the Construction Manager or Owner at the project site during the entire time of construction.

B. General Field Office Requirements:
   1. The field office, equipped as specified herein, shall be provided at the site, ready for use by the Construction Manager or Owner.
   2. Unless released earlier by the Construction Manager in writing, the field office shall be maintained in full operation at the site with all utilities connected and operable until the Notice of Completion has been executed or recorded. Upon execution or recordation of the Notice of Completion, or upon early release of the field office by the Construction Manager the Contractor shall remove the field office(s) within 14 days from the date of notification, and shall restore the site to its original condition.

C. Office Facilities:
   1. The Contractor shall provide all necessary electrical wiring, plumbing, toilet and lavatory fixtures, air conditioning and heating equipment, and shelving, and shall furnish all necessary light, heat, water, and daily janitorial services in connection with the field office specified herein, for the duration of the Work.
   2. The Contractor shall provide and maintain for the exclusive use of the Construction Manager, and the Owner's representative and personnel, at a point convenient to the construction operations, one separate, well lighted, air conditioned, electrically heated field office the equivalent to a 12-foot x 60-foot mobile office with a toilet room, containing a water closet and lavatory partitioned off from the working area and outside door lock. The Contractor shall provide all furnishings, services, and equipment specified herein. The office shall be of the portable trailer type unless otherwise specifically authorized by the Construction Manager in writing and shall be separate unit, not attached or connected to any other structures. The office will have as a minimum two private offices, one conference room and one common area.

1.02 FIELD OFFICE FURNISHINGS

A. The Contractor shall provide the following listed items in good condition for the primary field office:
   1. 6 Standard 30 x 60-inch desk with not less than 3 drawers
   2. 1 Plan table 36 x 72-inch top; 36 inches high
   3. 1 Plan rack (all metal plan-hold type) capable of holding 6 sets of plans, complete with 6 standard all metal plan-hold clamps
   4. 6 Office chair, standard arm rest type, adjustable swivel tilt-back with casters
   5. 8 Office chair, stiff-leg type, no arm rest
   6. 5 Waste baskets

7. 2 Tack board 36 x 42 inches, well mounted
8. 1 Bottled water dispenser unit (supplying both hot and cold water) and bottled water service and continuous supply of paper cups
9. 1 4' x 8' conference room table
10. 2 3' x 5' office tables
11. Small refrigerator and freezer (Approx. 24” W x 72” H)
12. 1,000-Watt microwave oven with small cabinet to hold plates and utensils
13. 1 Freestanding book shelves, minimum 4 feet high. Nine linear feet of shelf space shall be provided in each.
14. 1 Whiteboard, 4' x 3' with erasable color markers and supplies.
15. 1 10-inch indoor/outdoor maximum/minimum thermometer

1.03 SPECIAL OFFICE EQUIPMENT

A. Printer and Copy Machine:
   1. The Contractor shall provide, for the exclusive use of the Construction Manager, one combination printer and copy machine.
   2. The copier/printer shall be Laser Writer automatic feed type and shall be complete with connecting cord for a computer, capable of reproducing original 8-1/2 x 11 and 11 x 17 originals on either 8-1/2 x 11 or 11 x 17 plain bond paper. The machine must have a stack-feed capability and collating capability.
   3. The Contractor shall furnish all necessary powders, chemicals, or other materials required for proper operation of the copy machine, exclusive of bond paper. The Construction Manager will supply all bond reproduction paper required.

1.04 FIELD WIFI SERVICE

A. The Contractor shall provide in the field office provided as specified herein, for the use of the Owner's or Construction Manager's employees in connection with performance of the work hereunder, WIFI Service, in good order.

1.05 FIELD OFFICE SERVICES

A. The field office required hereunder shall be provided with sufficient lighting to provide not less than 50 foot-candles at desk top height at each desk location. Exterior lighting shall be provided over the entrance door.

B. A minimum of four 110V AC duplex electric convenience outlets shall be provided in the office and in the conference room and common area. At least one such outlet shall be located on each wall. The electric distribution panel shall service not less than two 110V, 60 Hz circuits.

C. Where inside toilet facilities are not connected to outside plumbing, a flush-type chemical toilet with a holding tank shall be provided. All such sanitary waste material shall be regularly pumped out and the chemicals recharged. A continuous supply of toilet paper and paper towels shall be furnished for the toilet facility.

1.06 FIELD OFFICE UTILITIES

A. The Contractor shall make all provisions and pay all installation and other costs for the Contractor's and the Construction Manager's offices in order to provide power service, exterior lights and any local code and OSHA requirements. Contractor shall pay all monthly charges for the various services provided to the Construction Manager's office throughout the construction period.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials, equipment and furnishings may be new or used, but must be serviceable, adequate for the required purpose, and must not violate applicable codes for regulations.

PART 3 EXECUTION

3.01 PREPARATION

A. The Contractor shall fill and grade sites for temporary structures to provide surface drainage. Provide all-weather surfaced access roads and paths and parking areas.

3.02 INSTALLATION

A. The Contractor shall construct temporary field office on proper foundations and provide connections for utility services. He shall secure portable or mobile buildings when used. Steps and landings shall be provided at entrance doors and a thermometer mounted at a convenient outside location, not in direct sunlight.

3.03 LOCATION

A. The field office facilities shall be located within the Contractor's work area shown at specific site approved by the Construction Manager.

3.04 MAINTENANCE AND CLEANING

A. The Contractor shall provide periodic maintenance and cleaning for field offices, furnishings, and equipment.

3.05 REMOVAL

A. The Contractor shall remove temporary field offices, workshops and storage buildings, and contents and services at a time when no longer needed. Foundations and debris shall be removed; site shall be graded to required elevations and the area cleaned.

END OF SECTION

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SECTION 01 57 00

TEMPORARY CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. This specification changes a portion of 2017 APWA Standard Specification Section 01 57 00. All other provisions of the Section remain in full force and effect. Provide temporary facilities for the proper completion of the Work as required and specified.

B. Changes:
   1. Change the following paragraph in **Article 3.2 DUST AND MUD CONTROL** to:
      a. At a minimum, dust and mud control efforts shall include a daily sweeping of the work area streets. One sweeping shall take place at the end of the workday at a minimum, if needed additional sweeping shall take place midway through the workday. Additional efforts may be required as determined by the ENGINEER, OWNER, SWPPP inspector, or other representative.
   2. Add the following paragraph in **Article 3.2 DUST AND MUD CONTROL**:
      a. Contractor shall prepare, submit and implement a Fugitive Dust Control Plan with the Utah Department of Environmental Quality, Division of Air Quality.
   3. Change the following paragraph to **Article 3.3 SURFACE WATER CONTROL** to:
      a. Control all on-site surface water. Provide proper drainage so flooding of the site or changed flow conditions including path, quantity or quality onto an adjacent property does not occur.
   4. Add the following paragraph to **Article 3.3 SURFACE WATER CONTROL**:
      a. CONTRACTOR shall prepare a Storm Water Pollution Prevention Plan (SWPPP) specifically for this project in compliance with Salt Lake City and State of Utah requirements for Stormwater Discharges Associated with Construction and Land Disturbance Activities. CONTRACTOR shall comply with all Clean Water Act, City Ordinance and SWPPP requirements for the project.
      b. Some minimum erosion control and storm water protection components have been identified. These do not constitute all necessary components of a comprehensive SWPPP.
      c. The CONTRACTOR shall provide all labor, equipment, materials, and services necessary to complete the work.
         1) Site Map: Showing boundaries and BMPs that will be implemented.
         2) Concrete washout: Describe in detail how concrete washout will be contained and removed from the site.
         3) Concrete/Road cutting (must be contained): Describe in detail how concrete & road cutting dust and pollutants will be contained.
         4) Housekeeping BMPs: Describe in detail general housekeeping e.g. restroom (port-a-potty), dumpster(s), roll off container or cans, etc. Provide means for secondary containment of housekeeping BMPs to prevent discharge to the site or City Creek in the event of a spill or rain event.
         5) Erosion/sediment controls: Describe in detail the boundary controls to be used e.g. inlet protection, silt fence, fiber rolls, wattle, cut back, etc.

6) Offsite tracking prevention: Describe in detail how you will mitigate tracking dirt/mud outside of construction boundaries in compliance with the City's Clean Wheel Ordinance.

7) Dewatering: BMPs that will be used to sample and treat discharge before entering a waterway/storm drain e.g. dewatering bag, filter sock, check down dam, frac tank, etc. Any water the CONTRACTOR intends to send to the creek shall be sampled, tested, in compliance with the City's MS4 permit requirements, in compliance with the project's UPDES UTG permit requirements, and meet the receiving water quality standards before being discharged to the creek.AD1

d. The CONTRACTOR shall identify type and placement of BMPs.

e. The CONTRACTOR shall be responsible for implementation and maintenance of all BMPs.

f. The CONTRACTOR shall perform weekly inspections of the site for the duration of the project. Note: Inspection shall include housekeeping, placement and condition of all BMPs.

g. The CONTRATOR shall be responsible stabilizing and removing all temporary BMPs at the conclusion of the job.

h. If work is being performed outside the boundaries of Salt Lake City the CONTRACTOR shall contact the MS4 operator and comply to any additional stormwater pollution prevention requirements for that jurisdiction.

i. If CONTRACTOR is assessed fines for not meeting permit requirements, those costs will not be passed onto the OWNER.

j. Contractor Shall submit a Dewatering Control Plan (DCP) specifically for this project in compliance with Salt Lake City and the State of Utah requirements for discharges associated with dewatering activities (if applicable).AD1

5. Change the following paragraph to **Article 3.4 GROUND WATER CONTROL** to:
   a. Remove all dewatering facilities meeting inspector requirements when no longer required.
6. Add the following paragraph to **Article 3.4 GROUND WATER CONTROL**:
   a. Any ground water the CONTRACTOR intends to send to the creek shall be sampled, tested an in compliance with the City's MS4 permit requirements before being discharged to the creek.
7. Add the following **Article 3.7 Sanitation to Part 3 – Execution**

3.7 Sanitation

A. Toilet Facilities: Provide portable chemical toilets at each active work site or staging area for the use of employees. Toilets at construction job sites shall conform to the requirements of Part 1926 of the OSHA Standards for Construction.

1. Furnish at least one portable toilet at each active work site.

END OF SECTION

SECTION 01 57 29

INTEGRATED EXCAVATION PLAN

PART 1 GENERAL

1.01 REQUIREMENTS

A. CONTRACTOR shall provide a thorough Integrated Excavation Plan (IEP) that unifies the requirements for Excavation and Fill (31 23 00), Dewatering (31 23 19), Sheeting, Shoring, and Bracing (31 41 00), Vibration Control (31 41 01), Demolition 02 41 00, and Geotechnical Instrumentation and Monitoring (31 09 00).

1.02 SUBMITTALS

A. Submittals in accordance with the General Conditions and Section 01 33 00.

B. The CONTRACTOR shall submit drawings and complete design data showing the means, methods and equipment the CONTRACTOR proposes for the IEP. The CONTRACTOR shall submit information sufficient for the ENGINEER to understand how the following systems are to be integrated:

1. Excavation and Fill
2. Dewatering
3. Sheeting, Shoring, and Bracing
4. Vibration Control
5. Geotechnical Instrumentation and Monitoring
6. Demolition

C. The IEP shall be stamped by a Ground Control Specialist/Professional Engineer licensed in the State of Utah with at least ten (10) years of experience working in these types of ground conditions.

D. The Specialist/Professional Engineer shall have professional liability insurance coverage as specified in contract documents.

PART 2 PRODUCTS (NOT USED)

PART 3 REQUIREMENTS

A. The IEP shall address the necessary means and methods required that are deemed critical to the success of the project and thoroughly protect the owner's facilities.

B. For unshored excavations near existing structures, The Professional Engineer responsible for the IEP shall provide stamped calculations demonstrating a factor of safety of at least 1.30 for global stability and 1.25 against sliding based on a 0.30 sliding coefficient of friction.

C. The Professional Engineer responsible for the IEP shall provide stamped calculations demonstrating that construction traffic loads will be mitigated so as to not impact the Owner's facilities.

D. The Professional Engineer responsible for the IEP shall also address the excavation under the existing walls adjacent to by-pass piping, Operations and Admin building, Filter Building, and Fluoride Building. As well as proposed pipelines within the yard adjacent to the walls.

E. The Professional Engineer for the IEP shall be available during construction and will address any conditions or events that may arise. This Work will include developing solutions to these said conditions or events.

F. The IEP shall include a Contingency Plan that addresses:
   1. Thresholds and limitations of the plan
   2. Mitigation Actions
   3. Contact list for an incident, e.g. Incident Commander
   4. Communication (Internal and External)
   5. Resources

G. The IEP shall include a summary for the expectations of the plan's performance.

END OF SECTION

SECTION 01 58 00

PROJECT IDENTIFCATION AND SIGNS

PART 1 GENERAL

1.01 SECTIONS INCLUDED

A. Temporary on-site identification and informational signs to identify key elements of construction facilities and traffic routing.

1.02 1.2 SUBMITTALS

A. Sketch of informational signs.

1.03 1.3 QUALITY ASSURANCE

A. Sign Painter: Professional experienced in type of work required.

B. Finishes, Painting: Adequate to resist weathering and fading for scheduled construction period.

PART 2 PRODUCTS

2.01 SIGN MATERIALS

A. Structure and Framing: May be new or used, wood or metal, in sound condition, structurally adequate to work and suitable for specified finish.

B. Sign Surfaces: Exterior grade plywood
   1. Type 4'x4': 4-feet high by 4-feet wide
   2. Type 4'x8': 4-feet high by 8-feet wide
   3. Thickness: As required by standards to span framing members, resist wind loading, and to provide an eve, smooth surface without waves or buckles.

C. Rough Hardware: Galvanized steel or equal.

D. Paint: Exterior quality
   1. Background: White
   2. Lettering: Black
   3. Accents: Green

PART 3 EXECUTION

3.01 PROJECT INDENTIFICATON SIGNS

A. Content to include:
   1. Title of Project
   2. City logo and motto
   3. Name of Mayor

4. Names of City Council members and the district they represent
5. Names of professional consultants and their titles
6. Name of ENGINEER and title
7. Name of CONTRACTOR

B. Graphic design, style of lettering, colors: See Drawing

C. Paint exposed surfaces of supports, framing, and surface material; one coat of primer and one coat of exterior paint.

D. Erect on the site at a lighted location of high public visibility, adjacent to the main entrance to the site, as approved by ENGINEER.

3.02 INFORMATIONAL SIGNS

A. Size of signs and lettering: As required by regulatory agencies, or as appropriate to usage.

B. Colors: As required by regulatory agencies, otherwise of uniform colors throughout project.

C. Paint exposed surfaces: One coat of primer, and one coat of exterior paint.

D. Paint graphics in styles, sizes, and colors selected.

E. Install at a height for optimum visibility, on ground-mounted poles, or attached to temporary structural surfaces.

F. No Commercial or advertising signs will be allowed on the site of the Work.

3.03 MAINTENANCE

A. Maintain signs and supports in a neat, clean condition; repair damages to structure, framing, or sign.

B. Relocate information signs, as required by progress of the Work.

C. Remove graffiti from signs immediately.

3.04 REMOVAL

A. Remove signs, framing, supports, and foundations at completion of Project.

B. Repair landscaping, and surface improvements damaged by removal.

C. At the completion of the removal the sign becomes property of the OWNER.

PROJECT IDENTIFICATION SIGN
USE WITHIN SALT LAKE CITY LIMITS

Salt Lake City Corporation – Department of Public Utilities

PLANT UPGRADES PACKAGE 1 PROJECT
City Creek Treatment Plant – Project No. 512260079

BUILDING A BETTER CITY

ERIN MENDENHALL, MAYOR

CITY COUNCIL

District 1 VICTORIA PETRO	District 2 ALEJANDRO PUY	District 3 CHRIS WHARTON
District 4 EVA LOPEZ CHAVEZ	District 5 DARIN MANO	District 6 DAN DUGAN
	District 7 SARAH YOUNG	

LAURA BRIEFER, DIRECTOR

CONSTRUCTION COMPANY NAME
COMPANY ADDRESS
COMPANY PHONE NUMBER

CONTACT: INSPECTOR NAME
SALT LAKE CITY INSPECTOR
PHONE NO: 801-###-####

SALT LAKE CITY CORPORATION
AGNIESZKA MARSZALIK,
PROJECT MANAGER
PHONE NO: 801-483-6348

PUBLIC UTILITIES DISPATCH 801-483-6700

SEAL – 8" RADIUS "BLACK" BACKGROUND WHITE

TEXT SIZE / COLOR 2.5" – "BLACK"

TEXT SIZE / COLOR 1.0" – "BLACK"

¾" CDX PYLWOOD

TEXT SIZE / COLOR ¾" – "BLACK"

44" x 2" BAR "LIGHT GREEN"

TEXT SIZE / COLOR ½" – "BLACK"

4' x 4' PROJECT SIGN ATTACHED TO WOODEN OR METAL POSTS

NOTE: SEE APWA SPECIFICATION 01 58 00 FOR DETAILED INFORMATION REGARDING PROJECT SIGNS.

END OF SECTION

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SECTION 01 61 45

AREA EXPOSURE DESIGNATIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:
   1. This section designates area exposure types for each location, room, area, or space at the site of the Work.
   2. Area exposures are used to specify materials based on the corrosion environment that the material is exposed to when the materials for the component are not scheduled or otherwise identified for each specific installation (e.g., pipe, anchor bolts, pipe supports, coatings, etc.). Where materials are scheduled for specific individual components (e.g., equipment, instruments, conduit, panels, etc.), furnish materials as specified.

1.02 RELATED SECTIONS:

A. Section 01 11 80 – Environmental Conditions

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Atmospheric: Air space surrounding a structure or process.
   2. Solution: Liquid or solid which may contain water or other free liquid.

B. EXPOSURE TYPE: Included as a supplement to this Section, the Area Exposure Table designates an Exposure Type for each room or area. Each Exposure Type, listed from least to most severe corrosion potential, is defined below:
   1. Indoor Dry: locations inside a building or other enclosed structure not subjected to wash down and not in contact with a liquid holding or earth retaining wall.
   2. Indoor Wet: locations inside a building or structure that are damp, subject to wash down, or surfaces of structures that are in contact with a liquid holding or earth retaining wall or slab.
   3. Outdoor: locations not protected from the weather, or only partly protected by a roof or open enclosure, and exposed to exterior ambient conditions. Local ambient conditions may be expected to vary, generally within the ranges specified in Section 01 11 80.
   4. Buried: below grade wall or roofs; locations covered and in contact with earth/soil.
   5. Submerged: locations inside a covered liquid or solids holding structure that are below a plane located 12 inches below the minimum operating level of the liquid in the tank or structure.
   6. Process Corrosive: locations exposed to high humidity, frequent wash down and/or corrosive gases or vapors from the process stream. Process corrosive includes locations inside an open (not covered) liquid or solids holding structure that are above a plane located 12 inches below the minimum operating level of liquid in the structure and below the top of the wall of the structure.

7. Head Space: locations inside a covered liquid or solids holding structure that are above a plane that starts 1-foot below the minimum operating liquid level in the structure.
8. Chemical Corrosive: walls, ceilings, floors, trenches and other surfaces exposed to delivery, storage, transfer, use or containment of corrosive chemicals.

C. ENVIRONMENTAL CONDITIONS: Environmental conditions for each Exposure Type are tabulated below:

Exposure Type	Environment	Chemical Exposure	Chemical Concentration
Indoor Dry	Atmospheric, Dry	None	Not Applicable
Indoor Wet	Atmospheric, Wet	None	Not Applicable
Outdoor	Atmospheric, Wet	None	Not Applicable
Buried	Solution	Earth/Soil	Not Applicable
Submerged	Solution	Various Chemicals	Dilute
Process Corrosive	Atmospheric	Hydrogen Sulfide	1 - 10 ppm
		Chlorides	Dilute
		Ferric chloride	45% wt
		Sodium hypochlorite	5.5 % wt
		Trace Chemicals	Dilute
Head Space	Low Oxygen, Wet	Hydrogen Sulfide	10 - 1500 ppm
		Other trace gases	Dilute
Chemical Corrosive	Atmospheric, Wet	Ferric chloride	45% wt
		Sodium hypochlorite	5.5% wt

D. AREA EXPOSURE TABLE: The Area Exposure Table schedules an Exposure Type for each location, room, area, or space at the site of the Work. The Area Exposure Table is provided in Part 4 of this Section.

PART 2 NOT USED

PART 3 EXECUTION

A. MATERIAL SELECTION
1. Provide construction materials, coating systems, and lining systems consistent with materials requirements specified in individual equipment/material Specifications for the exposure assigned in the area exposure table. In the event of a conflict between the individual equipment/material specification and this Section, the individual equipment/material specification governs. In the event an area exposure is not designated for a particular location, the area exposure with the most severe corrosion potential from all area exposures for adjacent locations, rooms, areas, or spaces governs, and shall be the basis of the Contract Price.
2. Where components are assigned multiple area exposures, select the material and coating specified for the area exposure that has the most severe corrosion potential. When components cross, span, or straddle the boundary separating two or more area exposures, select materials specified for the area exposure that has the most severe corrosion potential. Where materials change at a boundary between exposures, change the material at the boundary or within the less severe exposure. At material transitions, separate dissimilar metals by a dielectric coupling or other suitable barrier.

PART 4 AREA EXPOSURE TABLE

Area Number	Area Name	Room Number	Room Name / Delineation	Exposure Type	Notes
01	Site	---	Outside the perimeter of facilities, above grade	Outdoor	
01	Site	---	Outside the perimeter of facilities, below grade	Buried	
01	Site	---	Interior of below grade vaults and hand holes	Submerged	Does not include manholes on buried piping.
03	Operations Building	111	Electrical Room	Indoor Dry	
03	Operations Building	---	Other First Floor Areas	Indoor Wet	
03	Operations Building	113	Chemical Storage, exposed	Indoor Dry	
03	Operations Building	113	Chemical Storage, sumps	Chemical Corrosive	
35	Flocculation Basins	---	Upper level	Indoor Dry	
35	Flocculation Basins	---	Basin Interior, intermediate level, lower level	Submerged	
35	Sedimentation Basins	---	Upper level	Indoor Dry	
35	Sedimentation Basins	---	Basin Interior, intermediate level, lower level	Submerged	
35	Filters	---	Upper Level, filter gallery	Indoor Dry	
35	Filters	---	Filter inlet channel, filter basins, below Grade	Submerged	
60	Clarifier	---	Upper level	Outdoor, wet	
60	Clarifier	---	Lower level	Submerged	
70	Clearwell	---	Upper level, intermediate level	Indoor Dry	
70	Clearwell	---	Lower level	Submerged	
87	Fluoride	---	Upper level	Indoor dry	
87	Fluoride	---	Sumps	Chemical Corrosive	

END OF SECTION

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SECTION 01 66 00

PRODUCT STORAGE AND HANDLING REQUIREMENTS

PART 1 GENERAL

1.01 DAMAGE

A. Equipment, products and materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the Construction Manager.

1.02 PIPE

A. Pipe and appurtenances shall be handled, stored, and installed as recommended by the manufacturer. Pipes with paint, tape coatings, linings or the like shall be stored to protect the coating or lining from physical damage or other deterioration. Pipes shipped with interior bracing shall have the bracing removed only when recommended by the pipe manufacturer.

PART 2 EQUIPMENT

2.01 PACKAGE AND MARKING:

A. All equipment shall be protected against damage from moisture, dust, handling, or other cause during transport from manufacturer's premises to site. Each item or package shall be marked with the number unique to the specification reference covering the item.

B. Stiffeners shall be used where necessary to maintain shapes and to give rigidity. Parts of equipment shall be delivered in assembled or subassembled units where possible.

2.02 IDENTIFICATION:

A. Each item of equipment and valve shall have permanently affixed to it a label or tag with its equipment or valve number designated in this contract. Marker shall be of stainless steel. Location of label will be easily visible.

2.03 SHIPPING:

A. Bearing housings, vents and other types of openings shall be wrapped or otherwise sealed to prevent contamination by grit and dirt.

B. Damage shall be corrected to conform to the requirements of the contract before the assembly is incorporated into the work. The Contractor shall bear the costs arising out of dismantling, inspection, repair and reassembly.

2.04 FACTORY APPLIED COATINGS:

A. Unless otherwise specified, each item of equipment shall be shipped to the site of the work with the manufacturer's shop applied epoxy prime coating as specified in Section 09 90 00 . The prime coating shall be applied over clean dry surfaces in accordance with the coating manufacturer's recommendations. The prime coating will serve as a base for field-applied finish coats. Electrical equipment and materials shall be painted by manufacturer as specified in Section 09 90 00-3.03 Electrical and Instrumentation Equipment and Materials.

2.05 STORAGE:

A. During the interval between the delivery of equipment to the site and installation, all equipment, unless otherwise specified, shall be stored in an enclosed space affording protection from weather, dust and mechanical damage and providing favorable temperature, humidity and ventilation conditions to ensure against equipment deterioration. Manufacturer's recommendations shall be adhered to in addition to these requirements.

B. Equipment and materials to be located outdoors may be stored outdoors if protected against moisture condensation. Equipment shall be stored at least 6 inches above ground. Temporary power shall be provided to energize space heaters or other heat sources for control of moisture condensation. Space heaters or other heat sources shall be energized without disturbing the sealed enclosure.

2.06 PROTECTION OF EQUIPMENT AFTER INSTALLATION:

A. After installation, all equipment shall be protected from damage from, including but not limited to, dust, abrasive particles, debris and dirt generated by the placement, chipping, sandblasting, cutting, finishing and grinding of new or existing concrete, terrazzo and metal; and from the fumes, particulate matter, and splatter from welding, brazing and painting of new or existing piping and equipment. As a minimum, vacuum cleaning, blowers with filters, protective shieldings, and other dust suppression methods will be required at all times to adequately protect all equipment. During concreting, including finishing, all equipment that may be affected by cement dust must be completely covered. During painting operations, all grease fittings and similar openings shall be covered to prevent the entry of paint. Electrical switchgear, unit substation, and motor load centers shall not be installed until after all concrete work and sandblasting in those areas have been completed and accepted and the ventilation systems installed.

END OF SECTION

SECTION 01 71 13

MOBILIZATION AND DEMOBILIZATION

This specification changes a portion of APWA Standard Specification Section 01 71 13. All other provisions of the Section remain in full force and effect.

Add the following paragraph:

1.5 **SUBMITTALS**

A. Project Video Recording: Video record the project area prior to commencing construction. The ENGINEER's representative shall be present during recording. The recording shall be performed on foot, noting all salient existing features in the project area and the location of the recording shall be clearly indicated. "Drive-by" video recording will not be accepted. The video recording shall be submitted to the ENGINEER a minimum of 5 days prior to starting construction.

END OF SECTION

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SECTION 01 73 24

DESIGN REQUIREMENTS FOR
NON-STRUCTURAL COMPONENTS AND NON-BUILDING STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Minimum structural requirements for the design, anchorage, and bracing of non-structural components such as architectural/mechanical/HVAC/electrical components, equipment, or systems, and non-building structures such as tanks.

B. The requirements of this section apply to design of the structural elements and features of equipment and to platforms/walkways that are provided with equipment or non-building structures.

C. This section applies to non-building structures and non-structural components that are permanently attached to structures as defined below and in ASCE 7.

D. Design and conform to criteria and design codes listed within this section. Engineering design is not required for attachments, anchorage, or bracing detailed on the Drawings or where the size of attachments, anchorage, or bracing is defined in specific technical specification sections.

E. The following non-structural components are exempt from seismic design loading requirements of this section.
   1. Components in Seismic Design Category A.
   2. Furniture (except permanent floor supported storage cabinets over 6 ft tall).
   3. Temporary or movable equipment.
   4. Architectural components in Seismic Design Category B other than parapets supported by bearing walls or shear walls provided that the component importance factor, I_p, is equal to 1.0.
   5. Mechanical and electrical components in Seismic Design Category B.
   6. Mechanical and electrical components in Seismic Design Category C provided that the component importance factor, I_p, is equal to 1.0.
   7. Mechanical and electrical components in Seismic Design Categories D, E, or F where all of the following apply:
      a. The component importance factor, I_p, is equal to 1.0;
      b. The component is positively attached to the structure;
      c. Flexible connections are provided between the component and associated ductwork, piping, and conduit;
      d. And either:
         1) the component weighs 400 lb or less and has a center of mass located 4 ft or less above the adjacent floor level; or
         2) the component weighs 20 lb or less, or in the case of a distributed systems, 5 lb/ft or less.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related section. Additional related sections may apply that are not specifically listed below.
   1. Section 05 05 20 Anchor Bolts
   2. Section 05 50 00 Metal Fabrications

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
AAMA	American Architectural Manufacturer's Association
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3	Seismic Design of Liquid-Containing Concrete Structures
AISC 341	Seismic Provisions for Structural Steel Buildings
ACI 360	Specification for Structural Steel Buildings
ASCE 7	Minimum Design Loads for Buildings and Other Structures
FMDS	FM Global Property Loss Prevention Data Sheets
ASTM C635	Manufacture, Performance and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
ASTM C636	Installation for Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
AWS D1.1	Structural Welding Code – Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code – Stainless Steel
AWS D1.8	Structural Welding Code – Seismic Supplement
IBC	International Building Code with local amendments
ICC-ES AC 156	Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-structural Components
NFPA-13	Installation of Sprinkler Systems
OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration
SMACNA	Seismic Restraint Manual Guidelines for Mechanical Systems

1.04 DEFINITIONS

A. Structure: The structural elements of a building that resist gravity, seismic, wind, and other types of loads. Structural components include columns, posts, beams, girders, joists, bracing, floor or roof sheathing, slabs or decking, load-bearing walls, and foundations.

B. Non-structural Components: Non-structural portions of a building include every part of the building and all its contents, except the structural portions, that carry gravity loads and that may also be required to resist effects of wind, snow, impact, temperature and seismic loads. Non-structural components include, but are not limited to, ceilings, partitions, windows, equipment, piping, ductwork, furnishings, lights, etc.

C. Non-building Structures: Self-supporting structures that carry gravity loads and that may also be required to resist the effects of wind, snow, impact, temperature and seismic loads. Non-building structures include, but are not limited to, pipe racks, storage racks, stacks, tanks, vessels and structural towers that support tanks and vessels.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations to specification requirements, with the submittal is sufficient cause for rejection of the entire submittal with no further consideration.
   4. For structural elements of non-structural components and non-building structures required to be designed per this section, provide Drawings and design calculations stamped by a Utah licensed professional engineer qualified to perform structural engineering.
   5. List of non-structural components and non-building structures requiring wind and seismic design and anchorage.
   6. Shop drawings showing details of complete wind and seismic bracing and anchorage attachment assemblies including connection hardware, and embedment into concrete.
   7. Shop drawings showing plans, elevations, sections and details of equipment support structures and non-building structures, including anchor bolts, structural members, platforms, stairs, ladders, and related attachments.
   8. Identify interface points with supporting structures or foundations, as well as size, location, and grip of required attachments and anchor bolts. Clearly indicate who will be providing each type of attachment/anchor bolt. Equipment vendor shall design anchor bolts, including embedment into concrete, and submit stamped calculations.
   9. Calculations for supports, bracing, and attachments shall clearly indicate design criteria applied. Coordinate concrete embedment calculations with thickness and strength of concrete members. Submit a tabulation of the magnitude of unfactored (service level) equipment loads at each support point, broken down by type of loading (dead, live, wind, seismic, etc.). Indicate impact factors applied to these loads in design calculations.

10. Special Seismic Certification for non-structural components identified in article 1.07 of this section.
11. Submit all non-structural seismic anchorage and bracing submittals and corresponding structural calculations to FM Global representative for review in addition review by the Engineer(s).

1.06 QUALITY ASSURANCE

A. Quality Control By Owner:
   1. Special Inspection of non-structural components and non-building structures, and their anchorages shall be performed by the Special Inspector under contract with the Owner and in conformance with IBC Chapter 17. Special Inspector(s) and laboratory shall be acceptable to the Owner in their sole discretion. Special Inspection is in addition to, but not replacing, other inspections and quality control requirements. Where sampling and testing required conforms to Special Inspection standards, such sampling and testing need not be duplicated.
   2. For non-structural components requiring Special Seismic Certification, the Special Inspector shall verify that the label, anchorage, and mounting conform with the Special Seismic certificate of compliance.

1.07 SPECIAL SEISMIC CERTIFICATION

A. Special Seismic Certification is certification of equipment and components to not only withstand the effects of earthquakes, but also to function following the design seismic event.

B. Special Seismic Certification is required for the following non-structural components in Seismic Design Categories C through F, which have a component importance factor of I_p=1.5 (referred to as “Designated Seismic Systems” in ASCE 7):
   1. Components required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems and fire dampers.
   2. Components that contain or convey toxic, hazardous, or explosive substances where the quantity of the material exceeds threshold quantities established by the governing code authority, or the component is attached to a structure classified as a hazardous occupancy.
   3. Components in gor attached to a Risk Category IV structure and needed for continued operation.

C. Non-structural components requiring Special Seismic Certification could include, but are not limited to, the following:
   1. Fire protection systems and dampers.
   2. Makeup air units, supply ducts, exhaust ductwork, inline exhaust fans, furnaces, condensing units, and instantaneous water heaters.
   3. Electrical MCC’s, switchgear, panelboards, transformers, generators, control panels (fire alarm), and PLC panels.

D. Methods for Achieving Special Seismic Certification

1. For active components (e.g. equipment with parts that rotate, move mechanically, or are energized during operation), Special Seismic Certification is achieved by the following method, unless the component is listed below as being considered inherently rugged:
    a. Shake table testing (see below for requirements).
2. For non-active components and active components listed below as being considered inherently rugged, Special Seismic Certification is achieved by one of the following methods:
    a. Analysis demonstrating a complete load path and capacity of components to resist loading, including seismic loading calculated in accordance with design criteria in this section.
    b. Shake table testing (see below for requirements).
    c. Experience data meeting requirements described in ASCE 7, Chapter 13.
3. The following non-structural components could be considered "inherently rugged":
    a. Rigid and anchored process mechanical equipment such as pumps.
    b. Electrical conduit and cable tray.
    c. Gas/domestic water/vent/refrigerant piping.
4. Shake table testing requirements:
    a. In accordance with ICC-ES AC 156.
    b. Test for a minimum S_{DS} (0.2 second design spectral response) shown in the design criteria in this section.
    c. Base testing on a ratio of height of component attachment in structure with respect to base of structure of z/h equal to 1.0.
    d. Mount equipment in the shake table test in a similar manner to mounting on the project (e.g. mounting to floor vs wall vs suspended mounting, and rigid vs isolated mountings).

PART 2 PRODUCTS

2.01 GENERAL

A. Provide materials in conformance with information shown on the Drawings and in other technical specification sections. See individual component and equipment specifications for additional requirements.

2.02 DESIGN CRITERIA

A. Design Codes

Design	Code
Buildings/Structures:	International Building Code 2021, FMDS, and ASCE 7-16
Reinforced concrete:	ACI 350-20 and ACI 350.3-20 for Concrete Liquid Containing Structures, ACI 318-19 for all other reinforced concrete
Structural steel:	AISC 360-16 and AISC 341-16
Aluminum:	Aluminum Design Manual, Latest Edition
Welding:	AWS Welding Codes, Latest Edition
Occupational health and safety requirements:	OSHA

Note: When conflicting requirements occur, the most stringent requirements will govern the design.

B. Design Loads

1. Design non-structural components and non-building structures for the following minimum loads: (Do not apply wind and snow loads to non-structural components and non-building structures that are located inside buildings.)
2. Dead Loads:
   a. Add an additional allowance for piping and conduit when supported and hung from the underside of equipment and platforms.
   b. Typical allowance for piping and conduit: 20 psf
3. Uniform Live Loads:

Elevated grating floors:	100 psf
Columns:	No column live load reduction allowed
Exitways, stairs and landings:	100 psf
Equipment platforms, walkways/catwalks (other than exitways):	60 psf
Utility bridges:	75 psf per level

4. Snow Loads:

Code:	IBC 2021,FMDS & ASCE 7-16
Risk Category:	IV
Ground Snow Load (p_g):	70 psf
Exposure Factor (C_e):	C
Thermal Factor (C_t):	1.0
Importance Factor (I_s):	1.2
Flat Roof Snow Load (p_f):	65 psf
Drifting:	Per ASCE 7 & FMDS

5. Wind Loads:

Code:	IBC 2021, FMDS & ASCE 7-16
Risk Category:	IV
Basic Wind Speed (Ultimate, 3-second gust) for Risk Category Shown Above:	120 mph
Exposure:	C
Topographic Factor (K_{zt})	1.0

Note:

1. *Design exterior non-structural components and non-building structures, unless located in a pit or basin, to withstand design wind loads without consideration of shielding effects by other structures.*

6. Seismic Loads:

Code:	IBC 2018 & ASCE 7-16
Risk Category:	IV
0.2 Sec. Mapped Spectral Response, S_S:	1.229 g
1.0 Sec. Mapped Spectral Response, S_1:	0.456 g
Site Class:	B
0.2 Sec. Design Spectral Response, S_{DS}:	0.74 g
1.0 Sec. Design Spectral Response, S_{D1}:	0.24 g
Importance Factor (I_e):	1.5
Component Importance Factor (I_p):	1.0, except I_p=1.5 for components identified in Section 13.1.3 of ASCE 7
Seismic Design Category	D

Notes:

1. *Calculate seismic loads on the basis of governing building code. Include equipment operating loads in structure dead load.*
2. *Check individual members for seismic and full member live load acting simultaneously, except that flooded equipment loads (infrequent occurrence) need not be combined with seismic loads. Combine equipment operating loads with seismic loads.*

7. Impact Loads:
   a. Consider impact loads in design of support systems.
   b. Use the following impact load factors unless recommendations of the equipment manufacturer will cause a more severe load case:

Rotating machinery:	20% of moving load
Reciprocating machinery:	50% of moving load
Monorail Hoists:	
• Vertical	25% of lifted load
• Longitudinal	10% of lifted load
Hangers supporting floors and platforms:	33% of live and dead load

8. Temperature:
   a. Include effects of temperature in design where non-structural components and non-building structures are exposed to differential climatic conditions. See climatic conditions below for temperature extremes.

C. Load Combinations
   1. Design non-structural components and non-building structures to withstand load combinations as specified in the governing building code. Where the exclusion of live load or impact load would cause a more severe load condition for the member under investigation, ignore the load when evaluating that member.

D. Design Considerations
   1. Design non-structural components and non-building structures for the following conditions:
   2. Climatic Conditions:

Maximum design temperature:	90	degrees Fahrenheit
Minimum design temperature:	15	degrees Fahrenheit

   3. Foundations:
      a. Extend foundations supporting non-structural components and non-building structures below the frost line, or support on non-frost susceptible structural fill down to the frost line.

Frost line for foundations:	36 inches

Note: Consult project geotechnical report for allowable soil bearing recommendations at location of structure.

E. Column Base Fixity
   1. Design column bases as pinned connections. No moments shall be assumed to be transferred to foundations.
   2. Where significant shear loads (greater than 5,000 lb. per anchor bolt) are transferred at column base plates, provide a shear key designed to transfer shear load.

F. Deflection
   1. Maximum beam deflection as a fraction of span for walkways and platforms: L/240 for total load and L/360 for live load.
   2. Maximum total load deflection for equipment support: L/450.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments and braces in such a manner that component force is transferred to the lateral force-resisting system of the structure. Base attachment requirements and size and number of braces per calculations submitted by Contractor.

B. Anchorage of equipment is specified to be made by cast-in anchor bolts in concrete elements unless specifically noted otherwise on the Drawings or other specification sections. Contractor is responsible for remedial work or strengthening (of concrete elements because of superimposed seismic loading) if anchor bolts are improperly installed or omitted due to lack of submittal review or improper placement for any reason, at no additional cost to Owner.

C. Provide anchor bolts in accordance with Section 05 05 20. Base size of anchor bolts and embedment on submitted calculations.

D. Submit details of and calculations for anchorages prior to placement of concrete or erection of other structural supporting members. Submittals received after structural supports are in place will be rejected if proposed anchorage method would create an overstressed condition of the supporting member. Contractor is responsible for revisions to anchorages and/or strengthening of structural support so that there is no overstress condition, at no additional cost to Owner.

END OF SECTION

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SECTION 01 75 18

DISINFECTION

PART 1 GENERAL

1.01 SCOPE

A. Section includes: Cleaning and disinfection requirements for new and existing facilities located downstream of the first point of disinfectant application that are affected by the Work. The first point of disinfectant application is at the plant inlet Parshall flume.

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.

B. U.S. Environmental Protection Agency (EPA):
   1. Safe Drinking Water Act (SDWA).

1.03 SUBMITTALS

A. Submit disinfection test plan which details procedure to be utilized to disinfect the facilities including:
   1. Method and locations of disinfectant application.
   2. Locations of sampling points.
   3. Method of flushing and location of flushing ports (as appropriate for method of chlorination).
   4. Method of dechlorination (as appropriate for method of chlorination).
   5. Disposal location for chlorinated water (as appropriate for method of chlorination).

B. Submit disinfection reports and include the following:
   1. Date issued.
   2. Project name and location.
   3. Treatment subcontractor's name, address, and phone number.
   4. Type and form of disinfectant used.
   5. Time and date of disinfectant injection start.
   6. Time and date of disinfectant injection completion.
   7. Test locations.
   8. Initial and 24-hour disinfectant residuals in milligrams per liter for each outlet tested.
   9. Time and date of flushing start.
   10. Time and date of flushing completion.
   11. Disinfectant residual after flushing in milligrams per liter for each outlet tested.

C. Submit required permits, including but not limited to permit clearance.
   1. Coordinate with Owner and Engineer to obtain any necessary signatures.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect chlorine and bacteriological samples against damage and contamination.

B. Maintain caution labels on hazardous materials.

C. Maintain storage room dry and with temperatures as uniform as possible between 60 degrees Fahrenheit and 80 degrees Fahrenheit.

1.05 PROTECTION

A. Provide necessary signs, barricades, and notices to prevent persons from accidentally consuming water or disturbing system being treated.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disinfectant: Free chlorine in liquid, powder, tablet, or gas form in accordance with AWWA C653.

B. Dechlorination agent: Sulfur dioxide, sodium bisulfate, sodium sulfite, sodium thiosulfate, or ascorbic acid in accordance with AWWA C653.

PART 3 EXECUTION

3.01 PRELIMINARY CLEANING

A. Complete hydrostatic/leakage tests prior to disinfection.

B. Clean newly constructed and/or modified facilities located downstream of the first point or disinfectant application including flocculation basins, bypass piping, sedimentation basins, filters and conveyance facilities, such as pipes and channels at the plant, in accordance with AWWA C653 and the following:
   1. Remove debris and material not associated with the structure or process prior to disinfection.
   2. Clean wall, floor, ceiling, and attached surfaces by use of high-pressure water jet, sweeping, scrubbing, or equally effective means.
   3. Remove water, paint flakes, sediment, dirt, and foreign material accumulated during cleaning.
   4. Remove by flushing or other means, soil and debris from water pipes and channels in accordance with AWWA C651.
   5. Protect surfaces from adverse environmental exposure between the preliminary cleaning and the disinfection stages.

C. Prior to chlorination, clean newly constructed and/or modified facilities to be disinfected in accordance with AWWA C651, C652, or C653, as applicable.

D. Provide necessary blind flanges, hoses, sample taps, or any other appurtenances that may be required to clean and disinfect the piping and wetted surfaces.

3.02 SURFACES TO BE DISINFECTED

A. All treatment building process piping and basins in contact with raw, settled, or finished water including, but not limited to:
   1. Floc inlet piping
   2. Floc basins
   3. Sedimentation basins
   4. Filter inlet channel
   5. Filters
   6. Filter outlet pipe
   7. New backwash piping
   8. Constant head box
   9. Clearwells
   10. Backwash storage basins and pump station
   11. Plant water piping

B. New plant water plumbing and eyewash stations

C. Chemical piping and systems
   1. Sodium hypo chlorite systems
   2. Fluoride piping and carrier water system

D. Finished water pipes
   1. New Morris pipe
   2. New City pipe

3.03 DISINFECTION OF WATER TREATMENT STRUCTURES AND PIPING

A. Disinfect new and existing water treatment process structures and piping located downstream of the first disinfectant application point that are affected by the work. Disinfection shall be performed in accordance with AWWA C651, C652, and C653 as applicable.

B. Test for disinfectant residual at locations as specified in Disinfection Test Plan:
   1. Inlet and outlet piping.
   2. Coordinate sampling and testing with the Owner.

C. When disinfectant residual in the flocculation basins and bypass piping is less than 1 parts per million after 24 hours, repeat disinfection process.

3.04 DISPOSAL OF CHLORINATED WATER

A. Dispose of chlorinated water in accordance with the submitted disinfection test plan and applicable requirements of federal, state, county, and city having jurisdiction over disposal of hazardous wastes in location of the Project and disposal site.

B. A sanitary sewer system is not available at this site. Chlorinated water may only be disposed of in the backwash clarifier or the solids drying beds, in coordination with OWNER. Chlorinated discharge water shall be dechlorinated to a residual less than 2 parts per million before being discharged to the clarifier or the solids drying beds.

3.05 BACTERIOLOGICAL TEST

A. The Owner will conduct bacteriological tests. The Contractor shall coordinate with Owner.

END OF SECTION

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SCOPE

A. Operation and maintenance (O&M) instructions shall be provided in accordance with this section and as required in the technical sections of this project manual. O&M information shall be provided for each maintainable piece of equipment, equipment assembly or subassembly, and material provided or modified under this contract.

B. O&M instructions must be submitted and accepted before on-site training may start.

1.02 TYPES OF INFORMATION REQUIRED

A. General:
   1. O&M information shall contain the names, addresses, and telephone numbers of the manufacturer, the nearest representative of the manufacturer, and the nearest supplier of the manufacturer's equipment and parts. In addition, one or more of the following items of information shall be provided as applicable.

B. Operating Instructions:
   1. Specific instructions, procedures, and illustrations shall be provided for the following phases of operations:
      a. Safety Precautions: List personnel hazards for equipment and list safety precautions for all operating conditions.
      b. Operator Prestart: Provide requirements to set up and prepare each system for use.
      c. Start-Up, Shutdown, And Post shutdown Procedures: Provide a control sequence for each of these operations.
      d. Normal Operations: Provide control diagrams with data to explain operation and control of systems and specific equipment.
      e. Emergency Operations: Provide emergency procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include emergency shutdown instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance on emergency operations of all utility systems including valve locations and portions of systems controlled.
      f. Operator Service Requirements: Provide instructions for services to be performed by the operator such as lubrication, adjustments, and inspection.
      g. Environmental Conditions: Provide a list of environmental conditions (temperature, humidity, and other relevant data) which are best suited for each product or piece of equipment and describe conditions under which equipment should not be allowed to run.

C. Preventive Maintenance:
   1. The following information shall be provided for preventive and scheduled maintenance to minimize corrective maintenance and repair:
      a. Lubrication Data: Provide lubrication data, other than instructions for lubrication in accordance with paragraph 1.02 Operator Service Requirements.
         1) A table showing recommended lubricants for specific temperature ranges and applications;
         2) Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities; and
         3) A lubrication schedule showing service interval frequency.
      b. Preventive Maintenance Plan And Schedule: Provide manufacturer's schedule for routine preventive maintenance, inspections, tests, and adjustments required to ensure proper and economical operation and to minimize corrective maintenance and repair. Provide manufacturer's projection of preventive maintenance man-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft.

D. Corrective Maintenance:
   1. Manufacturer's recommendations shall be provided on procedures and instructions for correcting problems and making repairs.
      a. Troubleshooting Guides And Diagnostic Techniques: Provide step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.
      b. Wiring Diagrams And Control Diagrams: Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job-specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type identically to actual installation numbering.
      c. Maintenance And Repair Procedures: Provide instructions and list tools required to restore product or equipment to proper condition or operating standards.
      d. Removal And Replacement Instructions: Provide step-by-step procedures and list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings, and adjustments required. Instructions shall include a combination of test and illustrations.
      e. Spare Parts And Supply Lists: Provide lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonably delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead time to obtain.
      f. Corrective Maintenance Manhours: Provide manufacturer's projection of corrective maintenance man-hours including craft requirements by type of craft. Corrective maintenance that requires participation of the equipment manufacturer shall be identified and tabulated separately.

E. Appendices:
   1. The following information shall be provided; include information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment.
      a. Parts Identification: Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number which will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies.
      b. Warranty Information: List and explain the various warranties and include the servicing and technical precautions prescribed by the manufacturers or contract documents to keep warranties in force.
      c. Personnel Training Requirements: Provide information available from the manufacturers to use in training designated personnel to operate and maintain the equipment and systems properly.
      d. Testing Equipment And Special Tool Information: Provide information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.03 TRANSMITTAL PROCEDURE

A. Unless otherwise specified, O&M manuals, information, and data shall be transmitted in accordance with Section 01 33 00 accompanied by Transmittal Form 01 78 23-A and Equipment Record Forms 01 78 23-B and/or 01 78 23-C, as appropriate, all as specified in Section 01 99 90. The transmittal form shall be used as a checklist to ensure the manual is complete. Only complete sets of O&M instructions will be reviewed for acceptance.

B. Two (2) hard copies of the specified O&M information shall be provided. For ease of identification, each manufacturer's brochure and manual shall be appropriately labeled with the equipment name and equipment number as it appears in the project manual. The information shall be organized in the binders in numerical order by the equipment numbers assigned in the project manual. The binders shall be provided with a table of contents and tab sheets to permit easy location of desired information.

C. If manufacturers' standard brochures and manuals are used to describe O&M procedures, such brochures and manuals shall be modified to reflect only the model or series of equipment used on this project. Extraneous material shall be crossed out neatly or otherwise annotated or eliminated.

1.04 PAYMENT

A. Acceptable O&M information for the project must be delivered to the Construction Manager prior to the project being 65 percent complete. Progress payments for work in excess of 65 percent completion will not be made until the specified acceptable O&M information has been delivered to the Construction Manager.

1.05 FIELD CHANGES

A. Following the acceptable installation and operation of an equipment item, the item's instructions and procedures shall be modified and supplemented by the Contractor to reflect any field changes or information requiring field data.

END OF SECTION

SECTION 01 78 39

PROJECT RECORD DOCUMENTS

PART 1 GENERAL

1.01 DRAWINGS

A. Record drawings refer to those documents maintained and annotated by the Contractor during construction and are defined as
   1. a neatly and legibly marked set of contract drawings showing the final location of piping, equipment, electrical conduits, outlet boxes and cables;
   2. additional documents such as schedules, lists, drawings, and electrical and instrumentation diagrams included in the specifications; and
   3. Contractor layout and installation drawings.

B. Unless otherwise specified, record drawings shall be full size and maintained in a clean, dry, and legible condition. Record documents shall not be used for construction purposes and shall be available for review by the Construction Manager during normal working hours at the Contractor's field office. At the completion of the work, prior to final payment, all record drawings shall be submitted to the Construction Manager.

C. Marking of the drawings shall be kept current and shall be done at the time the material and equipment are installed. Annotations to the record documents shall be made with an erasable colored pencil conforming to the following color code:
   1. Additions - Red
   2. Deletions - Green
   3. Comments - Blue
   4. Dimensions - Graphite*

**Legibly mark to record actual depths, horizontal and vertical location of underground raceways, cables, and appurtenances referenced to permanent surface improvements.*

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 USE DURING CONSTRUCTION

A. Record Documents shall be maintained in a clean, dry, and legible condition.

B. Record Documents shall not be used for construction purposes and shall be available for review by the Construction Manager during normal working hours at the Contractor's field office.

3.02 UPDATES

A. Marking of the Record Documents shall be kept current and shall be done at the time the material and equipment are installed.

B. Annotations to the Record Documents shall be made with an erasable colored pencil conforming to the following color code:
   1. Additions – Red
   2. Deletions – Green
   3. Comments – Blue
   4. Dimensions – Graphite*

**Legibly mark to record actual depths, horizontal and vertical location of underground raceways, cables, and appurtenances referenced to permanent surface improvements.*

C. Monthly Review Meetings:
   1. During the monthly project meetings, the Contractor and Construction Manager shall review the record documents.
   2. At that time the Contractor and Construction Manager shall review the working set of record drawings and initial the accepted areas where everyone has agreed that the location, elevation and/or other construction modification is at the indicated final location.
   3. At the conclusion of each meeting, the Contractor shall submit the up-to-date Record Drawings to the Construction Manager.

D. Underground Utilities:
   1. Contractor shall provide digital photographs of underground piping and conduits, a fixed measurement on the record drawings, and/or GPS coordinates showing locations from buildings or structures prior to burying piping or electrical conduit.
   2. Contractor shall note the depth of buried piping and electrical conduit.

3.03 SUBMISSION

A. At the completion of the work, prior to final payment, all record drawings shall be submitted to the Construction Manager.

B. The electrical and instrumentation record drawings are typically the last mark ups to be completed. Final payment shall be withheld until the Contractor, Construction Manager, and Engineer have reviewed, verified and agreed on the final electrical and instrumentation record drawings.

END OF SECTION

SECTION 01 79 00

DEMONSTRATION AND TRAINING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for training the Owner's personnel, by persons retained by the Contractor specifically for the purpose, in the proper operation and maintenance of the equipment and systems installed under this contract.

1.02 QUALITY ASSURANCE

A. Where required by the detailed specifications, the Contractor shall provide on-the-job training of the Owner's personnel. The training sessions shall be conducted by qualified, experienced, factory-trained representatives of the various equipment manufacturers. Training shall include instruction in both operation and maintenance of the subject equipment.

1.03 SUBMITTALS

A. The following information shall be submitted to the Construction Manager in accordance with the provisions of Section 01 33 00. The material shall be reviewed and accepted by the Construction Manager as a condition precedent to receiving progress payments in excess of 50 percent of the contract amount and not less than 3 weeks prior to the provision of training.
   1. Lessons plans for each training session to be conducted by the manufacturer's representatives. In addition, training manuals, handouts, visual aids, and other reference materials shall be included.
   2. Subject of each training session, identity and qualifications of individuals to be conducting the training, and tentative date and time of each training session.

PART 2 PRODUCTS

2.01 GENERAL

A. Where specified, the Contractor shall conduct training sessions for the Owner's personnel to instruct the staff on the proper operation, care, and maintenance of the equipment and systems installed under this contract. Training shall take place at the site of the work and under the conditions specified in the following paragraphs. Approved operation and maintenance manuals shall be available at least 30 days prior to the date scheduled for the individual training session.

2.02 LOCATION

A. Training sessions shall take place at the site of the work in City Creek WTP Operations Building conference room and the new water treatment plant as applicable.

2.03 LESSON PLANS

A. Formal written lesson plans shall be prepared for each training session. Lesson plans shall contain an outline of the material to be presented along with a description of visual aids to be utilized during the session. Each plan shall contain a time allocation for each subject.

B. One complete set of originals of the lesson plans, training manuals, handouts, visual aids, and reference material shall be the property of the Owner and shall be suitably bound for proper organization and easy reproduction. The Contractor shall furnish ten copies of necessary training manuals, handouts, visual aids and reference materials at least 1 week prior to each training session.

2.04 FORMAT AND CONTENT

A. Each training session shall be comprised of time spent both in the classroom and at the specific location of the subject equipment or system. As a minimum, training session shall cover the following subjects for each item of equipment or system:
   1. Familiarization
      a. Review catalog, parts lists, drawings, etc., which have been previously provided for the plant files and operation and maintenance manuals.
      b. Check out the installation of the specific equipment items.
      c. Demonstrate the unit and indicate how all parts of the specifications are met.
      d. Answer questions.
   2. Safety
      a. Using material previously provided, review safety references.
      b. Discuss proper precautions around equipment.
   3. Operation
      a. Using material previously provided, review reference literature.
      b. Explain all modes of operation (including emergency).
      c. Check out Owner's personnel on proper use of the equipment.
   4. Preventive Maintenance
      a. Using material previously provided, review preventive maintenance (PM) lists including:
         1) Reference material.
         2) Daily, weekly, monthly, quarterly, semiannual, and annual jobs.
      b. Show how to perform PM jobs.
      c. Show Owner's personnel what to look for as indicators of equipment problems.
   5. Corrective Maintenance
      a. List possible problems.
      b. Discuss repairs--point out special problems.
      c. Open up equipment and demonstrate procedures, where practical.
   6. Parts
      a. Show how to use previously provided parts list and order parts.
      b. Check over spare parts on hand. Make recommendations regarding additional parts that should be available.

7. Local Representatives
    a. Where to order parts: name, address, telephone.
    b. Service problems:
        1) Who to call.
        2) How to get emergency help.
8. Operation and Maintenance Manuals
    a. Review any other material submitted.
    b. Update material, as required.

2.05 VIDEO RECORDING:

A. The Owner will retain the services of a commercial video taping service to record each training session. After taping, the material will be edited and supplemented with professionally produced graphics to provide a permanent record. The Contractor shall advise all manufacturers providing training sessions that the material will be video taped and shall make available to the Owner's video taping contractor such utility services and accommodation as may be required to facilitate the production of the video tape record.

PART 3 EXECUTION

3.01 SUMMARY

A. Training shall be conducted in conjunction with the operational testing and commissioning periods. Classes shall be scheduled such that classroom sessions are interspersed with field instruction in logical sequence. The Contractor shall arrange to have the training conducted on consecutive days, with no more than 6 hours of classes scheduled for any one day. Concurrent classes shall not be allowed. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

B. Acceptable operation and maintenance manuals for the specific equipment shall be provided to the Owner prior to the start of any training. Video taping shall take place concurrently with all training sessions.

C. The following services shall be provided for each item of equipment or system as required in individual specification sections. Additional services shall be provided, where specifically required in individual specification sections.
    1. As a minimum classroom equipment training for operations personnel will include:
        a. Using slides and drawings, discuss the equipment's specific location in the plant and an operational overview.
        b. Purpose and plant function of the equipment.
        c. A working knowledge of the operating theory of the equipment.
        d. Start-up, shutdown, normal operation, and emergency operating procedures, including a discussion on system integration and electrical interlocks, if any.
        e. Identify and discuss safety items and procedures.
        f. Routine preventative maintenance, including specific details on lubrication and maintenance of corrosion protection of the equipment and ancillary components.
        g. Operator detection, without test instruments, of specific equipment trouble symptoms.

h. Required equipment exercise procedures and intervals.
i. Routine disassembly and assembly of equipment if applicable (as judged by the Owner on a case-by-case basis) for purposes such as operator inspection of equipment.

2. As a minimum, hands-on equipment training for operations personnel will include:
   a. Identify location of equipment and review the purpose.
   b. Identifying piping and flow options.
   c. Identifying valves and their purpose.
   d. Identifying instrumentation:
      1) Location of primary element.
      2) Location of instrument readout.
      3) Discuss purpose, basic operation, and information interpretation.
   e. Discuss, demonstrate, and perform standard operating procedures and round checks.
   f. Discuss and perform the preventative maintenance activities.
   g. Discuss and perform start-up and shutdown procedures.
   h. Perform the required equipment exercise procedures.
   i. Perform routine disassembly and assembly of equipment if applicable.
   j. Identify and review safety items and perform safety procedures, if feasible.
3. Classroom equipment training for the maintenance and repair personnel will include:
   a. Theory of operation.
   b. Description and function of equipment.
   c. Start-up and shutdown procedures.
   d. Normal and major repair procedures.
   e. Equipment inspection and troubleshooting procedures including the use of applicable test instruments and the "pass" and "no pass" test instrument readings.
   f. Routine and long-term calibration procedures.
   g. Safety procedures.
   h. Preventative maintenance such as lubrication; normal maintenance such as belt, seal, and bearing replacement; and up to major repairs such as replacement of major equipment part(s) with the use of special tools, bridge cranes, welding jigs, etc.
4. Hands-on equipment training for maintenance and repair personnel shall include:
   a. Locate and identify equipment components.
   b. Review the equipment function and theory of operation.
   c. Review normal repair procedures.
   d. Perform start-up and shutdown procedures.
   e. Review and perform the safety procedures.
   f. Perform Owner approved practice maintenance and repair job(s), including mechanical and electrical adjustments and calibration and troubleshooting equipment problems.

END OF SECTION

SECTION 01 81 13.01

SUSTAINABLE DESIGN REQUIREMENTS

PART 1 GENERAL

1.01 DESCRIPTION:

A. Envision is a sustainability certification framework developed by the Institute for Sustainability Infrastructure (ISI, https://sustainableinfrastructure.org) that includes 64 sustainability and resilience credits organized around five categories: Quality of Life (QL), Leadership (LD), Resource Allocation (RA), Natural World (NW), and Climate and Resilience (CR). There are five levels of achievement under each credit. The levels of achievement, in order of increasing point value, are Improved, Enhanced, Superior, Conserving, and Restorative. Envision is designed for infrastructure projects and will be applied campus-wide for the City Creek Treatment Plant Upgrades Project. Based on a pre-assessment, the project team has agreed that pursuing Gold certification is feasible under the Envision v3 framework. As the project progresses, if Gold certification is no longer considered feasible, the project team will reconvene to discuss, and the OWNER may adjust Envision requirements accordingly.

B. Documentation of sustainability practices from design through long term operation of the WTP to meet framework requirements is the basis of project certification by ISI.

C. This section includes general requirements and procedures for compliance with specific Envision credits needed for the Project to obtain Envision Gold certification (i.e., at least 40 percent of total applicable points must be met under Envision Version 3, 2018).

D. The following Envision credits require compliance during construction:
   1. QL1.3 Improve Construction Safety
   2. QL1.6 Minimize Construction Impacts
   3. QL3.3 Enhance Local Views and Character
   4. RA1.1 Support Sustainable Procurement Practices
   5. RA1.2 Use Recycled Materials
   6. RA1.4 Reduce Construction Waste
   7. RA1.5 Balance Earthwork on Site
   8. RA2.2 Reduce Construction Energy Consumption
   9. RA3.3 Reduce Construction Water Consumption
   10. NW2.2 Manage Stormwater
   11. NW3.4 Control Invasive Species
   12. NW3.5 Protect Soil Health

1.02 REFERENCES:

A. Institute for Sustainable Infrastructure (ISI) (https://sustainableinfrastructure.org/): Envision – Version 3

1.03 ADMINISTRATIVE REQUIREMENTS:

A. The Contractor shall respond to questions and requests from the Engineer, the Owner, and ISI regarding the Envision credits or other sustainability requirements documented here in that are the responsibility of the Contractor. These responses may include documentation for product selection or product qualities, or queries regarding on the Contractor's procedures. These responses may be documented as design RFIs (DRFIs) or informational submittals.

B. Contractor will designate a person as the Envision Coordinator. This person can have other project responsibilities but shall be the point person for all Envision-related meetings, workshops, questions, reporting, etc.

C. The Envision Coordinator shall:
   1. Be ISI Envision Certified and remain Certified for the duration of the Work.
   2. Ensure compliance with the sustainability requirements as identified and provided in the construction documents and agreed to for the Envision certification process.
   3. Provide monthly reporting (written and verbal) of inventories related to sustainable procurement (RA1.1), recycled materials (RA1.2), construction waste diverted (RA1.4), earthwork (RA1.5), and energy (RA2.2) and potable water consumption during construction (RA3.3).
   4. Provide sustainability submittal documentation from applicable Manufacturers as agreed to and requested by the Engineer and Owner.
   5. Attend monthly Envision coordination meetings.
   6. Provide a monthly log of progress on sustainability/Envision requirements evaluated and implemented throughout the entire Project as agreed to by the Contractor, Engineer and Owner.
   7. Provide a draft Envision Action Plan within 30 days of Notice to Proceed and include the following:
      a. Envision Coordinator Contact Information.
      b. Construction Management Plan for complying with identified Envision credits.
   8. Incorporate comments on Envision Action Plan and finalize the document within 90 days of Notice to Proceed.
   9. Update Envision Action Plan as needed throughout the construction project.

1.04 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 45 00.

B. Sustainability Standards Certifications.

C. Envision Coordinator: Notify the Engineer of changes in personnel performing the Envision Coordinator function.

D. The Owner reserves the right to reject products and assemblies based on incomplete or inaccurate submittals.

1.05 SUBMITTALS:

A. Submit the following documents in accordance with Section 01 33 00.
   1. Envision Action Plan.
   2. Sustainability Submittals to meet documentation requirements as described herein.

1.06 ENVISION CRITERIA & SUSTAINABILITY SUBMITTAL REQUIREMENTS:

A. Refer to the Envision Manual – Version 3 for more information related to the criteria outlined below.

B. The Owner, Engineer and Contractor have preliminarily agreed to target achieving the Envision criteria listed herein. Contractor will make every reasonable effort to support the Project in meeting these criteria. Based on budget and schedule constraints, these targeted levels of achievement will be revisited throughout construction and may be modified by the Team as agreed to and directed by the Owner to better reflect achievable levels of achievement.

C. QL 1.3 Improve Construction Safety:
   1. Targeted Level of Achievement: Conserving
      a. Contractor makes strong commitments to monitor and improve health and safety for onsite construction operations.
      b. Documentation is created to track health and safety performance, promote best practices during construction, and to correct any deficiencies.
      c. Safety and security competency training for all field personnel are conducted as specified in project safety plan. Contractor provides at least the minimum training requirements.
      d. Contractor has a specific site and project site security plan and provides at least minimum training requirements.
      e. Contractor provides programs that promote health and wellbeing and provides documentation indicating such.

D. QL1.6 Minimize Construction Impacts:
   1. Targeted Level of Achievement: Conserving
      a. A Construction Management Plan is implemented to address the temporary inconveniences to stakeholders associated with construction. Plan is informed by stakeholder engagement performed and communicated by Owner/Owner's representative.
      b. The Construction Management Plan addresses four types of construction impacts to stakeholders: noise, safety/wayfinding, access/mobility, or lighting.
      c. The Construction Management Plan describes robust feedback mechanisms and performance monitoring and reporting for construction impacts to be provided by the Owner/Owner's representative.

E. QL3.3 Enhance Local Views and Character:
   1. Targeted Level of Achievement: Superior:
      a. The Construction Management Plan identifies how character features, high value landscapes, or landscape features will be protected during construction.

F. RA1.1 Support Sustainable Procurement Practices:
   1. Targeted Level of Achievement: Improved
      a. A minimum of 5 percent (by weight, cost, or volume) of the purchased materials shall follow sustainable practices as identified and described by Salt Lake City Policy 6.01.07 Sustainable Procurement.

G. RA1.2 Use Recycled Materials:
   1. Targeted Level of Achievement: Improved
      a. A minimum of 5 percent (by weight, cost, or volume) of the purchased materials shall be considered recycled materials with recycled content and/or reused existing structures or materials.
      b. Provide documentation to demonstrate the targeted level of achievement has been met.

H. RA1.4 Reduce Construction Waste:
   1. Targeted Level of Achievement: Enhanced
      a. A Construction Waste Management Plan developed within the first 60 days of construction and implemented that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on site or commingled.
      b. A minimum of 50 percent (by weight or volume) of the waste materials shall be recycled, reused and/or salvaged.

I. RA1.5 Balance Earthwork on Site:
   1. Targeted Level of Achievement: Improved
      a. Excavated material moved off site and / or fill brought onto the site does not exceed 70% of total site soil handling or
      b. 100% of fill and excavated materials are sourced or reused within 25 mi/40 km of the site.
      c. RA2.2 Reduce Construction Energy Consumption:
   2. Targeted Level of Achievement: Enhanced
      a. Planning reviews are used to identify and analyze options for reducing energy consumption during construction.
      b. At least two (2) energy reduction strategies are implemented and documented.

J. RA3.3 Reduce Construction Water Consumption:
   1. Targeted Level of Achievement: Enhanced
      a. Planning reviews are used to identify and analyze options for reducing water consumption during construction.
      b. At least three (3) potable water conservation strategy are implemented.

K. NW2.2 Manage Stormwater:
   1. Targeted Level of Achievement: Improved
      a. The project will include an erosion, sedimentation, and pollutant control plan for construction activities.

L. NW3.4 Control Invasive Species:
   1. Targeted Level of Achievement: Restorative
      a. Best practices are used to prevent unintentional introduction of known invasive species to the site.
      b. The Construction Management Plan includes provisions for preventing the introduction of invasive species (plant or animal).
      c. The Construction Management Plan establishes a program that controls minor infestations of invasive species on site before and throughout construction.
      d. Contractor establishes and implements a program that controls minor infestations of invasive species on site before and throughout construction. Plan will incorporate Salt Lake Department of Public Utilities Watershed Division's Guide to Identify and Control Common Invasive Weeds.
      e. Contractor guards against future infestations by supporting the establishment of native and/or noninvasive species.

M. NW3.5 Protect Soil Health:
   1. Targeted Level of Achievement: Enhanced
      a. The project limits the area that is disturbed by development activities.
      b. At least 95% of post-construction vegetated areas disturbed during construction are restored for appropriate soil type, structure, and function to support healthy plant and tree growth.

1.07 QL1.3 IMPROVE CONSTRUCTION SAFETY:

1. Contractor shall submit documentation of strong commitments to monitor and improve health and safety for onsite construction operations.
2. Contractor shall submit documentation of tracking health and safety performance, promoting best practices during construction, and correcting any deficiencies.
3. Contractor shall submit documentation of safety and security competency training programs.
4. Contractor shall submit documentation of a specific site and project security plan.
5. Contractor shall submit documentation of programs that promote health and wellbeing.

B. QL1.6 Minimize Construction Impacts:
   1. Contractor shall submit a Construction Management Plan that addresses concerns from stakeholders associated with the temporary inconveniences of construction and mitigation measures for at least four of the following: noise, safety/wayfinding, access/mobility, or lighting. The Construction Management Plan shall include robust feedback mechanisms and performance monitoring and reporting for construction impacts.
   2. Programs to monitor and inform impacted stakeholders on project performance in addressing construction impacts shall be documented.

C. QL3.3 Enhance Views and Local Character:
   1. Contractor shall submit a Construction Management Plan that addresses how the character features, high value landscapes, or landscape features will be protected during construction.

D. RA1.1 Support Sustainable Procurement Practices:
   1. Contractor shall submit an inventory of purchases with supporting calculations of the percentage of total project materials by cost, weight or volume that align with the sustainable procurement practices including a description of the materials, the Manufacturer or Supplier of the material, and evidence of the disclosure requirements.

E. RA1.2 Use Recycled Materials:
   1. Contractor shall submit an inventory of total materials used on the project by weight, volume, or cost (this must be consistent for all inventories).
   2. Contractor shall submit an inventory of materials containing recycled content including the name of the product, name of the manufacturer, the weight, volume, or cost of the material (consistent for all materials), and the percentage of recycled content (either post-industrial or post-consumer recycled content).
   3. Contractor shall submit an inventory of existing materials or structures that have been reused or salvaged including the location and weight, volume, or cost. In determining weight, volume, or cost, the project team may refer to standard equivalents.

F. RA1.4 Reduce Construction Waste:
   1. Contractor shall submit a Construction Waste Management Plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on site or commingled.
   2. Contractor shall submit an inventory of waste materials that have been recycled, reused, or salvaged including a general description of each type/category of construction and demolition materials generated, location and percentage of materials diverted by weight or volume.

G. RA1.5 Balance Earthwork on Site:
   1. Contractor shall submit documentation showing how the project reused at least 30% of earthwork onsite OR sourced and reused 100% of earthwork within 25 mi/40 km of the project site.

H. RA2.2 Reduce Construction Energy Consumption:
   1. Contractor shall submit documentation that one or more planning reviews were conducted to identify and analyze options for reducing energy consumption during construction.
   2. Contractor shall submit documentation that the project has implemented two (2) energy reduction strategies during construction as specified in the Envision V3 manual.

I. RA3.3 Reduce Construction Water Consumption:
   1. Contractor shall submit documentation that one or more planning reviews were conducted to identify and analyze options for reducing potable water consumption during construction.
   2. Contractor shall submit documentation that the project has implemented at least three (3) water conservation strategies during construction as specified in the Envision V3 manual.

3. Contractor shall submit calculation of potable water saved (gallons) for each strategy as compared to not implementing the strategy over the construction duration.

J. NW2.2 Manage Stormwater:
   1. Contractor shall submit documentation of an erosion, sedimentation, and pollutant control plan such as a Stormwater Pollution Prevention Plan (SWPPP) or Erosion and Sedimentation Control Plan (ESCP), for all construction activities associated with the project.

K. NW3.4 Control Invasive Species:
   1. Contractor shall submit a Construction Management Plan to prevent the introduction of invasive species. The plan includes best practices to ensure that construction materials and equipment used on site are free of invasive species and seeds.
   2. Contractor shall submit documentation of control, containment or suppression activities during construction for any major infestations of invasive species found on site.

L. NW3.5 Protect Soil Health:
   1. Contractor shall submit documentation showing how soil disturbance will be limited during construction.
   2. Contractor shall submit post-construction soil restoration plans, procedures and calculations for both post-constructed and existing vegetated areas. Calculations of soil restoration activities must constitute at least 95% of the post-construction vegetated areas on site.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 ENVISION CREDITS:

A. QL 1.3 Improve Construction Safety:
   1. Contractor shall comply with project safety plan.
   2. Contractor shall track health and safety performance and correct any deficiencies that are identified during construction as specified by the project safety plan.
   3. Contractor shall implement safety training for all field personnel as specified by the project safety plan.

B. QL1.6 Minimize Construction Impacts:
   1. Contractor shall implement procedures and policies to minimize construction impacts as specified by the Construction Management Plan.

C. QL 3.3 Enhance Views and Local Character:
   1. Contractor shall comply with the components of the Construction Management Plan that protect character features, high-value landscapes, or landscape features during construction.

D. RA1.1 Support Sustainable Procurement Practices:
   1. Contractor shall select materials that align with Salt Lake City Policy 6.01.07 Sustainable Procurement guidelines.

E. RA1.2 Use Recycled Materials:
   1. Contractor shall select recycled materials, materials with recycled content, and/or reused existing structures or materials in accordance with recycled materials requirement.

F. RA1.4 Reduce Construction Waste:
   1. Contractor shall recycle, reuse and/or salvage waste materials in accordance with the waste reduction requirement.

G. RA1.5 Balance Earthwork On Site:
   1. Contractor shall source fill and/or reuse cut from sites that meet credit requirements.

H. RA2.2 Reduce Construction Energy Consumption:
   1. Contractor shall attend planning reviews to identify and analyze options for reducing energy consumption during construction.
   2. Contractor shall implement two (2) energy reduction strategies identified during planning reviews.

I. RA3.3 Reduce Construction Water Consumption:
   1. Contractor shall attend planning reviews to identify and analyze options for reducing water consumption during construction.
   2. Contractor shall implement three (3) water conservation strategies identified during planning reviews.

J. NW2.2 Manage Stormwater:
   1. Contractor shall implement the programs for erosion, sedimentation and pollution control as specified in the erosion, sedimentation and pollutant control plan.

K. NW3.4 Control Invasive Species:
   1. Contractor shall implement the programs and policies for controlling invasive species throughout construction as specified by the Construction Management Plan.

L. NW3.5 Protect Soil Health:
   1. Contractor shall restore at least 95% of post-construction vegetated areas on site, including areas disturbed by development, to a condition that can support healthy plant and tree growth. Soils must be reused for functions comparable to their original function (i.e., topsoil is used as topsoil, subsoil as subsoil, or subsoil is amended to become function topsoil).

END OF SECTION

SECTION 01 91 00

COMMISSIONING, TESTING AND START-UP

PART 1 GENERAL

1.01 SUMMARY

A. This Section establishes the Contractor's responsibilities for developing and conducting the complete commissioning, including testing and startup, of all equipment, systems, and facilities (new or existing) which are defined within the Contract Documents. This effort and the associated experience requirements are significant and critical to a safe and successful startup that meets the project schedule requirements.

B. This Section provides the overarching guidelines for commissioning but does not supersede specific testing requirements found elsewhere in the Contract Documents. Where there is any discrepancy, Contractor shall assume the more stringent requirements control unless confirmed otherwise by the Engineer. Refer to Division 26 and Division 40 for specific execution requirements related to electrical and instrumentation components and systems. For pre-commissioning activities, refer to other technical specifications, including Division 03 for requirements for testing of concrete hydraulic structures and Section 40 05 01 for testing requirements of hydraulic structures and piping.

C. All commissioning activities must be coordinated early in the project to minimize interference with the operation of the existing facility, or delays to the project schedule; see Section 01 12 16 for project work sequence and constraints. Unless otherwise specified, or agreed to in advance by the Engineer, Owner and Construction Manager, no commissioning activities will be scheduled to take place on a weekend or holiday recognized by the Owner.

D. This Section contains specific references to the following related specification sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 11 00 Summary of Work
   2. Section 01 12 16 Work Sequence and Restrictions
   3. Section 01 32 16 Construction Progress Schedule
   4. Section 01 33 00 Submittal Procedures
   5. Section 01 45 23 Testing and Inspection Services
   6. Section 01 51 00 Temporary Utilities

E. The Contractor shall provide an experienced Commissioning Manager who will be responsible for overseeing, organizing, administering, recording, and documenting all aspects of the commissioning efforts.

F. A representative or representatives of the equipment manufacturer(s) shall participate in the commissioning phases per the requirements of the Specifications.

1. Commissioning Overview: The sequence of the commissioning shall proceed as follows. Variations to this sequence may be requested by the Contractor and may be authorized by the Engineer (with input from the Construction Manager) where necessary to meet other constraints described in these Contract Documents. Any requested changes to the extent of testing quality control checks, related sequencing, and/or level or frequency of documentation shall be considered a deviation from the accepted Commissioning Plan and require resubmittal. The equipment and facility startup is a bottom-up approach, where testing starts at the component level, which is then followed by testing at the system, and then facility level.
    a. Phase 1 Commissioning: Component Test Phase. The Component Test Phase is comprised of the following three parts.
        1) Part 1 – Component Installation Review
        2) Part 2 – Component Operational Test
        3) Part 3 – Component Network Communications Test
    b. Phase 2 Commissioning: Functional Test Phase
        1) Part 1 – Functional Test of Individual Components and Independent Systems
        2) Part 2 – Comprehensive Functional Test of Integrated Systems
    c. Phase 3 Commissioning: Operations Test Phase. The Operations Test Phase is comprised of the following two parts.
        1) Part 1 – Walkdown
        2) Part 2 – Seven (7) Day Operations Test
    d. Phase 4 Commissioning: Acceptance Test Phase
    e. Optimization/Performance Commissioning Phase
2. Unless otherwise specified or agreed to in writing by the Engineer (with input from the Construction Manager), all testing activities required as part of facility construction will occur prior to initiation of Phase 1 Commissioning. These include, but are not limited to, testing hydraulic structures for water tightness, pressure testing of piping systems, etc. Refer to applicable specification sections for specific requirements.

1.02 CONTRACTOR COMMISSIONING MANAGER RESPONSIBILITIES AND QUALIFICATIONS

A. The Contractor shall provide an experienced Commissioning Manager who will be responsible for overseeing, organizing, administering, recording, and documenting all aspects the testing and startup efforts, including development of System Commissioning Plans. Refer to paragraph 1.02 Contractor Commissioning Manager Responsibilities and Qualifications for experience requirements.

B. At 90 days prior to the commencement of the first component testing, the Commissioning Manager shall be full time, working only on the testing and startup activities of this Work.

C. The Commissioning Manager's responsibilities shall include, but are not limited to, the following activities.
   1. Direct and oversee the development of all commissioning planning documents.
   2. Coordinate and be responsible for all testing and startup activities.
   3. Coordinate activities with overall Contractor's project schedule, providing a schedule update at each meeting.
   4. Serve as liaison between the Contractor and the Engineer/Construction Manager for all testing and startup activities. Coordinate directly with Owner's staff as directed by the Construction Manager.
   5. Organize, lead, and provide minutes for Commissioning Meetings from the initial development of the System Commissioning Plans until the completion of all testing and startup activities.
   6. Maintain the System Commissioning Plans and provide monthly updates to the Startup Team until the month prior to startup, then provide weekly updates until commissioning is complete.
   7. Oversee and administer all testing activities, including either direct participation in the testing, and/or oversight and monitoring of all testing, and related documentation.
   8. Assure that all tests have been successfully completed in accordance with the submitted testing procedures.
   9. Develop, compile, review for completeness and compliance to the specifications, and submit all required completed test submittals and other related documentation in a timely manner.
   10. Work with the Contractor's Safety Supervisor to provide safe work conditions during commissioning.
   11. Prior to submittal, review and approve the content of all training sessions to assure that the training includes all applicable operation, maintenance, safety, and functional, operations, and acceptance testing information.

D. Commissioning Manager's Statement of Qualifications:
   1. Bachelor's degree in civil, mechanical, or electrical engineering with A minimum of 10 years of construction experience and 5 years of experience serving in a role with responsibilities similar to those described in this Section.
   2. Experience in the startup of similar systems on at least one completed drinking water treatment facility, with a minimum construction cost of $50 million; over 400 sheets of drawings; and including pumping, pipelines, equipment, liquid and/or solids treatment process modifications, networked controls, and electrical infrastructure.

1.03 DEFINITIONS

A. Commissioning:
   1. The systematic process composed of all elements and requirements related to testing and startup of the Work.

B. Commissioning Hierarchy:
   1. Area
      a. A collection of systems usually constructed within or primarily within the confines of a single building or structure.
      b. Generally, the Drawings are compiled by Area number, in ascending order. Area numbers used in the Drawings correspond with the numbering system utilized during the last several facility upgrades.
      c. In most cases, Areas correspond with treatment processes. In some cases, however, multiple treatment processes are included in the same Area and/or a single treatment process is incorporated into multiple Areas.
   2. System
      a. An arrangement of components or other systems so related or connected to perform a specific function and which form an identifiable, unified, functional, operational, safe, and independent part of the Owner's facility.
      b. A system may consist of solely new equipment installed as part of the Work, or as a combination of new equipment installed as part of the Work and existing equipment operating in conjunction with each other.
      c. A system may include equipment and facilities in more than one Area.
   3. Component
      a. Components comprise every discrete item associated within the Work.
      b. Example components include but are not limited to the following:
         1) Structural system components include: buildings, tanks and reservoirs.
         2) Architectural system components include: floors, walls, doors, windows, ceilings and roofs.
         3) Process system components are usually discrete pieces of equipment and their respective motors and include: pumps, tanks, blowers, and other types of treatment equipment.
         4) Piping system components include: the piping, the piping connections, and the valves, whether manual or powered.
         5) Electrical system components include: wiring, equipment including but not limited to panelboards, MCCs, starters, and VFDs.
         6) Control system components include: Wiring, instruments, control panels, human-machine interfaces (HMIs'), computers, programmable logic controllers (PLCs), instrument networks, and process control networks
         7) Heating, ventilation and air conditioning (HVAC) system components include: pumps discrete pieces of HVAC equipment, and their respective motors and include: pumps, heat pumps, heat exchangers, water quality systems, valves, fans, louvers and ductwork.
         8) Plumbing system components include: pumps, strainers, valves, water supply piping, and area collection/drainage for system
         9) Fire alarm system components include: fire alarms, and network communication.

10) Fire suppression system components include: sprinklers, valves, and piping.
11) Security system components include: video surveillance, locking systems, identification systems, access to existing or other systems, and security staffing.
12) Communication systems, including internet connectivity devices, speakers, and receivers.
13) Access control systems, including motorized gates and interface to existing and/or other systems.
14) Indoor and outdoor lighting control systems and interface to other systems.

C. Summary of Test Phases. Reference paragraph 3.05 Testing for comprehensive test phase requirements.
   1. Phase 1 Commissioning: Component Test Phase. The Component Test Phase is intended to:
      a. Perform inspection and testing in a logical, stepwise sequence to ensure that the installed components have been safely and properly assembled, serviced, aligned, adjusted, connected, and calibrated prior to operation.
      b. Perform operational tests to prove that the components are operating as needed, intended, and specified.
      c. Perform component network communications tests to prove that all network reporting, data received, and control aspects for a given component are being correctly performed as needed, intended and specified.
   2. Phase 2 Commissioning: Functional Test Phase. The Functional Test Phase is performed on a system, multiple integrated systems and/or a facility to prove that they function as required in conformance with the performance requirements and as needed, intended and specified. Functional tests use plant water, non-potable water, air, or simulated signals, not the specified media.
   3. Phase 3 Commissioning: Operations Test Phase. The Operations Test Phase prepares a system, multiple integrated systems or a facility for the Acceptance Test Phase, proves that all systems are correctly set up and that the facility will reliably function over time in real world conditions. The Operations Test Phase is intended to:
      a. Provide for operations testing to prove compliance with performance requirements using either raw water, plant water, non-potable water, air, or the specified media, depending on the tests performed.
      b. Perform a complete inspection (walkdown) by the commissioning team to verify readiness for the 7-day operational test.
      c. Provide for 7-day operations test which shall consist of a continuous un-interrupted seven-day run period using the specified media.

4. Phase 4 Commissioning: Acceptance Test Phase. The Acceptance Test Phase operates a system, multiple integrated systems or a facility with the specified media, by the Owner (with assistance from the Contractor), for 30 days, without operational or performance failure to demonstrate satisfactory performance with the performance requirements specified. Performance tests, specified in individual specification sections to verify guaranteed performance, are performed during Phase 4 Commissioning.
5. Optimization Commissioning Phase: Some systems may be specified with Optimization Testing which is intended to provide the Manufacturer's services to optimize specific systems.

D. Other Key Terms:
1. Tests: Unless otherwise specified, denotes all field-testing including component tests, functional tests, operational tests, acceptance tests, and optimization/performance tests.
2. Startup Constraints: Startup constraints are identified throughout these Contract Documents with major construction constraints with reference to the effects on process startup are being discussed in Section 01 12 16.
3. Commissioning Team. Led by the Commissioning Manager, the Commissioning Team is comprised of key operations and maintenance personnel of the Owner, the Construction Manager, the Engineer and key representatives of the Suppliers.
4. Commissioning Manager: A testing and startup expert employed by the Contractor who is responsible for overseeing, organizing, administering, recording, and documenting all aspects the commissioning efforts.
5. Temporary Provision: Outages, re-routes, systems, components, materials, or equipment which is temporarily required to allow any test to occur.
6. Integrator: party responsible for control panel fabrication or alteration
7. Programmer: responsible for configuration of controllers (PLC, DCS, RTUs), HMI software. This may be separate from the party responsible for the control panel, fabrications or alternation, instrument installation and configuration.
8. Vendor Programmer: party responsible for controllers or local interface on vendor package equipment, defined as separate from plant or area SCADA systems.

1.04 SYSTEMS FOR PRE-COMMISSIONING AND COMMISSIONING

A. The following are list the major areas and systems within those areas to be commissioned as individual packages:
1. Area 01 and 05: Septic System and Infiltration Gallery
a. System 1:
1) Septic Tank Pump System
2) [_____]
3) [_____]
b. System 2:
1) Infiltration Gallery Pump System
2) [_____]

3) [_____]

2. Area 20, 35, 50, 70, 71, 73, 84 and 89: Treatment Building
   a. System 1:
      1) Flocculators
      2) Hoseless Solids Collection/Blower System
      3) Filters
   b. System 2:
      1) Constant Head Backwash Pumping System
      2) Plant Water Pump System
      3) Backwash Tank Flow Control Valve
3. Area 89: Operations Building
   a. System 1:
      1) Flash Mix Chemical Feed System
      2) Sodium Hypochlorite Chemical Feed System
      3) [_____]
   b. System 2:
      1) Backup Power Generator and Fuel Tank System
      2) [_____]
      3) [_____]
      4) [_____]
4. Area 87: Fluoride Building
   a. System 1:
      1) Fluoride Chemical Feed System
      2) [_____]
      3) [_____]
   b. System 2:
      1) Groundwater Pump System
      2) [_____]
      3) [_____]
   c.
5. Area 60: Clarifier
   a. System 1:
      1) Recycle Water Pump System
      2) [_____]
      3) [_____]
   b. System 2:
      1) Clarifier Rake Arm Assembly
      2) [_____]
      3) [_____]
6. For all areas, facilities, equipment not explicitly included in the areas listed above, Contractor to provide listing of systems and equipment.

1.05 COMMISSIONING PLAN

A. The commissioning plan shall include:
   1. Provisions to maintain operations of the Direct Filtration treatment plant until an operating permit for the new treatment plant is obtained from the Utah Division of Drinking Water.
   2. Means and methods for discharging treated water to City Creek until new treatment plant is fully commissioned and is discharging water to the SLCDPU potable water distribution system.
   3. Means and methods to commission the systems according to the milestones outlined in Section 01 12 16 Work Sequence and Restrictions.

1.06 MANUFACTURER'S FIELD SERVICES

A. Where manufacturer's services are specified in this Section or other specification sections, furnish an authorized representative of the manufacturer who is factory-trained, knowledgeable and experienced in the technical aspects of their products and systems supplied on the Project and qualified to provide these services. Manufacturer representatives shall be available during equipment installation, commissioning and training of Owner's personnel.

B. Manufacturer's representatives shall be subject to the acceptance of by the Construction Manager and Engineer as a submittal with each System Commissioning Plan. No substitute representatives will be allowed without prior written approval from the Construction Manager.

C. Manufacturer's Certifications:
   1. After equipment installation and before equipment energization, each manufacturer's representative shall prepare a written Manufacturer's Installation Certification Form, Form 43 05 11-A in Section 01 99 90, certifying that each equipment specified in Divisions 26 through 46 that the manufacturer supplied is properly installed and lubricated, has been properly maintained by the Contractor, is in accurate alignment, is free from any undue stress imposed by connecting piping and anchor bolts, and is in accordance with the manufacturer's installation instructions.
   2. During Phase 4 Commissioning, each manufacturer's representative shall prepare a written Manufacturer's Operation Certification Form, Form 43 05 11-D in Section 01 99 90, certifying that each equipment specified in Divisions 26 through 46 that the manufacturer supplied is properly lubricated; has been properly maintained by the Contractor; is in accurate alignment; is free from any undue stress imposed by connecting piping and anchor bolts; and has been operated under all design conditions and meets the performance criteria in accordance with the requirements in the applicable specification sections and the manufacturer's operating requirements.

D. The Manufacturer's authorized representative shall perform all services when Manufacturer's services are specified in the individual specification sections. The authorized representative shall be factory-trained and experienced in the technical applications, installation, operation and maintenance of the equipment, subsystem or system.

E. The scheduling of all visits to the site by the manufacturer's field services representative shall be determined by the Contractor and coordinated through the Commissioning Manager. The Contractor shall notify the Construction Manager a minimum of 7 days in advance of all visits.

F. The Manufacturer's authorized representative shall not independently determine any requirements can be omitted, reduced or otherwise change testing requirements, protocols, or required documentation without submitting a request for deviation to the accepted Commissioning Plan or other related submittals.

1.07 SUBMITTALS

A. Action Submittals: The following minimum submittals shall be submitted in accordance with Section 01 33 00.
   1. Within 60 days following Notice to Proceed.
      a. A copy of this Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (") shall denote full compliance with a paragraph as a whole.
      b. If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations.
      c. The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.
      d. Commissioning Manager qualifications and past work experience including contact names, addresses, and current telephone numbers that can be used to verify the accuracy of the provided information.
   2. Within 120 days following Notice to Proceed.
      a. Master Commissioning Plan.

3. Not less than 120 days prior of the initiation of the first planned component testing in a system.
    a. System Commissioning Plan for the system within which the first components will be tested. Submit system test plans in two parts as described below:
        1) Submit the portion of the system commissioning plan for Component and Functional testing.
        2) After successful completion of the Component testing, submit the test plan for the remaining phases of testing and commissioning.
    b. Submit remaining System Commissioning Plans not less than 120 days prior to first planned component testing within each system, following the same two-part submittal process described above.
4. Qualifications of equipment manufacturer's representatives, to be submitted with each System Commissioning Plan.
5. Within 7 days following completion of each phase of Commissioning for each System Commissioning Plan, submit documentation demonstrating successful completion of the testing phase for that system. Any issues identified during the testing phase shall be identified along with the actions taken, or planned to be taken, to rectify the issue.
6. Certificates of instrument calibration, provided upon request from the Construction Manager or Engineer.

B. Informational Submittals: The following minimum informational submittals shall be submitted in accordance with the timing requirements specified in these Contract Documents, prior to Substantial Completion and in accordance with Section 01 33 00.
    1. Updates to Comprehensive Testing Schedule.

C. Closeout Submittals: The following minimum closeout submittals shall be submitted in accordance with the timing requirements specified in these Contract Documents, prior to Substantial Completion and in accordance with Section 01 33 00.
    1. Manufacturer's Certificates of Proper Installation, Form 43 05 11-A in Section 01 99 90, or reference to completed certificates provided under separate submittals where specified.
    2. Test Reports, including completed test forms as specified in Section 01 99 90, and paragraph 1.05 Commissioning Plan, or reference to completed test forms provided under separate submittals where specified.
    3. Certificate of Testing and Commissioning
    4. Certificate of Training Completion, Form 43 05 11-B in Section 01 99 90, or reference to completed Certificates of Training Completion provided under separate submittals where specified.
    5. Manufacturer's Certificates of Proper Operation, Form 43 05 11-D in Section 01 99 90, or reference to completed Manufacturer's Certificate of Proper Operation provided under separate submittals where specified.

D. Samples:
   1. Reference the individual specifications within the Contract Documents for items requiring samples to be submitted.

E. Mock-ups:
   1. Reference the individual specifications within the Contract Documents for items requiring mock-ups to be submitted.

PART 2 PRODUCTS

2.01 TEST MATERIALS AND EQUIPMENT

A. Provide calibrated test gauges, meters, recorders and monitors, reagents and test gases and associated assemblies, as required, to supplement or augment the Work specified in the Contract Documents to facilitate compliance with requirements of the commissioning. Select devices designed to measure the performance of the specific equipment and systems incorporated into the Work.

B. When testing requires the use of temporary provisions such as, but not limited to equipment, power, compressed air, or instrumentation which have not yet been placed in service, provide substitute sources acceptable to both the Owner and Construction Manager, and capable of meeting the requirements needed to perform the testing.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall install all equipment in accordance with Manufacturer's requirements and the Contract Documents. Notify the Engineer/Construction Manager of any conflict between a manufacturer's installation recommendations and the Contract Documents.

B. The Contractor shall perform component testing, functional testing, and startup testing, of all installed component and systems. Unless specified otherwise, the Owner shall be responsible for operating the facility during acceptance testing, with assistance and support from the Contractor in performing specific testing activities.

C. The Contractor shall provide the services of all technical and craft personnel required to support the Work throughout the duration of all testing phases, except as otherwise noted in this Section.

D. The Contractor shall maintain the appropriate staff (either on-site or on-call) to be able to respond immediately (24-hours per day) to deficiencies discovered during the Operations Test Phase and the Acceptance Test Phase. The Contractor's qualified personnel must be capable of being on-site within a maximum of 2 hours of notice to correct any deficiencies.

E. Owner's Operations and Maintenance Responsibility during Testing:
   1. Systems, multiple integrated systems, or facilities in the Operations Test Phase which require raw water to be treated and disposed of shall be operated by the Owner with guidance from the Commissioning Manager.
   2. Unless specified otherwise, systems, multiple integrated systems, or facilities in the Acceptance Test Phase shall be operated by the Owner with assistance and support from the Commissioning Manager.

F. Until completion of the Acceptance Test Phase, the Contractor shall maintain all facilities undergoing testing. This includes, but is not limited to, manufacturer recommended preventative maintenance, repairs as needed, consumables such as lubricants, coating touch-up, etc.

G. The Contractor shall provide temporary systems, piping, valving, drains, power, controls, etc. to facilitate any of the tests, as needed to cycle water or air through the facilities in a manner that simulates the ultimate operation of the system.

H. All testing that may affect the operation of the existing facilities shall be coordinated with the Owner, including the proper isolation (e.g., lock out/tag out) procedures and features prior to commencing Work.

I. Timing of Testing:
   1. No testing shall commence until the related specific System Commissioning Plan has been submitted, reviewed, and received a review action of No Exceptions Taken, or Make Corrections Noted.
   2. No testing shall commence until the O&M Manual for the equipment involved has been reviewed and received a review action of No Exceptions Taken or Make Corrections Noted.
   3. Progression from one test phase to the next shall only be allowed at the written approval of the Construction Manager, following submission of written documentation from the Contractor signifying that the intent of that testing phase has been met with satisfactory results. The written approval will include a listing of items still owed by the Contractor regarding the testing which has occurred.
   4. Operations Testing shall not commence until all tagging and labeling including but not limited to piping, conduit, wires, panels, and equipment, have been completed.
   5. Acceptance Testing shall not commence until training has been completed.
   6. All life-safety systems, including but limited to ventilation, fire monitoring and alarms, hazard monitoring and alarms, communication systems, associated with a specific system, must have successfully completed operations testing prior to proceeding with Functional Testing of the system.

J. At the satisfactory conclusion of each test phase, the Contractor shall dismantle and remove all temporary valving, hoses, and other equipment used during the test, and return the facilities to conditions as existed before the test.

K. All deficiencies found during any test phase and subsequent correction thereof, must be inspected and approved by the Construction Manager prior to re-testing or continuation of testing. The contractor shall correct all noted deficiencies.

3.02 TESTING AND STARTUP MEETINGS AND WEEKLY REPORTS

A. The Commissioning Manager shall conduct regular commissioning meetings.

B. The first meeting shall be at least 6 months prior to submitting the Project Commissioning Plan and shall include preliminary discussions regarding this plan. Commissioning meetings shall then be held monthly until 120 days prior to the first planned Component Testing. Ongoing development of the individual System Commissioning Plans will be among the topics discussed in these meetings.

C. At a point commencing 120 days prior to the first Component Test Phase, the commissioning meetings shall be held weekly.

D. Commissioning meetings shall be attended by the Construction Manager, key members from the Contractor staff, Subcontractors, key representatives of the Manufacturers, along with representatives for the Owner and the Engineer.

E. The Commissioning Manager shall prepare meeting minutes from the Testing and Start-up and distribute to all attendees not later than 3 days prior to the next meeting, or within 5 working days of each meeting, whichever is sooner. These should be issued as draft with a request for comments within 3 business days, followed by a final issuance.

F. Weekly Test Reports:
   1. During testing activities, submit weekly test reports describing the tests performed, test methods, test strategies implemented during the test, summary of successful testing completed, and specific highlight of any problems and/or deficiencies found during testing.
   2. For all troubleshooting, describe the troubleshooting strategy, methods, and final resolution.

3.03 EQUIPMENT AND MATERIALS REQUIRED FOR TESTING

A. It shall be the Contractor's responsibility to ensure that all required materials and test and repair equipment are on hand during all planned testing activities. Spare parts, specified to be provided as part of the work, shall not be used for testing without the written approval of the Construction Manager.

B. All instruments used to measure performance shall be calibrated. Certificates of calibration shall be current (as required in Division 40), and shall be at the job site during testing, and provided upon request or when specified.

C. Contractor is required to provide all expendables during all tests (not including Acceptance Testing, unless otherwise specified), including but not limited to, chemicals, fuel, oil and filters (e.g., air, fuel, natural gas, oil, media, etc.). Upon completion of Operational Testing (or Acceptance Testing, where specified) all expendables shall be replaced with new.

3.04 TEMPORARY PROVISIONS

A. Maintain temporary provisions until the testing phase requiring the temporary facilities are complete, or until the permanent facilities are in service where specified.

3.05 TESTING

A. Phase 1 Commissioning: Component Test Phase: The Component Test Phase shall be comprised of the following three parts.
   1. Part 1 – Component Installation Review
      a. Perform inspection and testing in a logical, stepwise sequence to ensure that the installed components have been safely and properly assembled, serviced, aligned, adjusted, connected, and calibrated prior to operation.
      b. Perform all changes, adjustments, and replacements required to make the equipment operate properly.
      c. The Component Installation Review includes but is not limited to the following activities.
         1) Verification of adherence to manufacturer's installation and pre-startup requirements and procedures.
         2) For structures and tanks, perform and confirm compliance of structural leakage tests in accordance with Division 03 of these specifications.
         3) For piping, perform and confirm compliance of piping testing in accordance with Section 40 05 01.
         4) Verify wiring continuity for all components, equipment, instruments, panels, and devices. Check power, control, and monitoring circuits for continuity prior to connection to power source. Reference Division 26 and Division 40 for additional specifics regarding installation review of electrical and controls components including, but not limited to:
            a) Electrical acceptance tests per Section 26 08 00, complete.
            b) Arc flash hazard and coordination study, protective device settings, and labeling completed.
         5) Confirm cleanliness of connecting piping systems.
         6) Confirm alignment of connected machinery.
         7) Confirm correct lubrication.
         8) Confirm valve orientation and position status for manual operating mode.
         9) Confirm correct tagging and identification
         10) Confirm proper functioning of all safety components.
         11) Confirm proper connections, alignment, calibration, and adjustment.
         12) Manually rotate or move all moving parts to assure freedom of movement.
         13) Confirm all safety equipment is installed per contract requirements, including but not limited to eye wash stations, warning signs, ventilation systems and equipment, etc.

14) Provide Manufacturer's Certificate of Proper Installation following the completion of this review.

2. Part 2 – Component Operations Test
    a. Perform testing showing that the component is operating as needed, intended, and specified for the Work including but not limited to the following.
        1) Bump electric motors to verify power and direction of rotation.
        2) Verify correct voltage and phase sequence of all circuits.
        3) Verify correct amperage.
        4) Loop tests per Section 40 61 21.
        5) Complete testing of all control circuits including interlocks.
        6) Verify that every component is operational through its entire range of operation.
    b. Reference Division 26 and Division 40 for specific execution requirements related to electrical and instrumentation components and systems.
    c. Unless otherwise specified or allowed by the Construction Manager, the test media for component operational testing shall be plant water or non-potable water.
3. Part 3 – Component Network Communications Test
    a. The component network communication tests shall prove that all network reporting, data received, and control aspects for a given component are being correctly performed as needed, intended, and specified.
    b. Perform network tests for all network panels, network hardware, network cables, and all other network systems that are required to be installed and operational for each component.
    c. Refer to Division 40 for specific execution requirements for the component network tests.

B. Phase 2 Commissioning: Functional Test Phase:
1. Functional testing shall be performed on all components and systems as required to prove that they function as required in conformance with the performance requirements and as needed and intended to complete the Work. All components of a system shall be operated together during functional testing.
    a. The Functional Test Phase is required for all process equipment, HVAC equipment, other equipment, piping, electrical, instrumentation, controls, and package system equipment.
    b. Testing for all DCS controls associated with all components with DCS monitoring or DCS controls shall be performed. This test shall include testing of multiple components that have interfaces between them. For packaged equipment this shall include testing of interfaces and interlocks between equipment supplied by the Supplier of the packaged equipment and equipment supplied in other technical specification sections.

c. When testing requires the use of auxiliary systems such as electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, provide acceptable substitute sources, capable of meeting the requirements of the component or system.

d. Functionally test each system as an independent system.
   1) Tests shall include all the functional requirements provided in Division 26 and Division 40, within the individual requirements in the Specifications and as required by the Supplier.
   2) Demonstrate that each, and every, component within the system interacts and functionally operates as specified throughout its entire range of operation.
   3) Test each interlock for the system, all local controls, and all DCS controls.

e. Functionally test multiple integrated systems. The testing shall include individual components and systems that were previously tested independently.
   1) Test in a step-by-step method to accomplish orderly and systematic testing of integrated systems to simulate the functionality of the completed Work.
   2) Tests shall be run through normal operating ranges and to prove specific performance requirements as required by the Specifications or otherwise needed to prove compliance with the Specifications.
   3) To the greatest extent practical, test at conditions which represent the full range of operating parameters (or specified test parameters if greater) as defined in the Contract Documents.
   4) The tests shall include all network controls, all network interlocks, all inter-process interlocks, and all operations interfaces.
   5) The tests shall be performed until the specified operating modes or performance has been accomplished without interruption for the specified duration as indicated in the Specifications or in no instance less than 4 hours.
   6) Should the functional testing of the integrated systems be halted for any reason, the testing shall be repeated until it has been accomplished without interruption.
   7) Coordinate with Construction Manager such that Construction Manager can witness each individual step in the procedures.

f. Following the testing perform the following.
   1) Check equipment for loose connections, unusual movement or other indications of improper operating characteristics.
   2) Disassemble and inspect equipment which exhibits unusual or unacceptable operating characteristics. Re-align machines identified as out of alignment. Repair, or remove and replace with new if unable to pass the requirement of the testing. Test until the equipment meets the requirements of the Specifications.

g. Unless otherwise specified or allowed by the Construction Manager and Engineer, the test media for functional testing shall be the water identified in the System Commissioning Plan (e.g., plant water, non-potable water, air, or specified media, depending on the system).

C. Phase 3 Commissioning: Operations Test Phase:
   1. General Requirements of the Operations Test Phase
      a. Tests shall be performed using the specified media.
      b. Disposal of test media shall follow all laws and regulations and with proper permits.
      c. Unless otherwise indicated in these Contract Documents or permitted by the Construction Manager, training shall be performed during the Operations Test Phase.
      d. The Operations Test Phase shall be conducted at a time and date which is requested by the Contractor and agreed to by the Owner.
      e. Coordinate with the Owner for introduction of specified media, disposal (or return to treatment plant) of specified material, and operation of facilities with specified media.
      f. Prior to commencement of the Operations Test Phase, the facility shall be fully operational, capable of accepting design flows and performing functions as designed.
      g. The Operations Test Phase shall test for normal operational sequence as an integrated system conforming to the requirements of the Specifications through full specified operating range. Test network control logic across multiple systems.
      h. During the Operations Test Phase, tests shall be executed for all components. Tests shall include all the operations tests as specified in the individual equipment technical specification sections. This includes vibration tests where specified.
      i. Provide required support to the Owner such that the facility attains its fully operational mode.
   2. Part 1 -Walkdown: After the completion of the functional testing, a complete inspection by the Startup Team shall be performed to determine if the facility is ready for the Seven (7) Day Operational Test.
      a. Walk through the facility with the Construction Manager, the Owner, and the Engineer to acknowledge facility is ready for the Seven (7) Day Operational Test.
      b. A working punch-list will be developed and provided by the Construction Manager.
      c. The punch-list shall be identified by the following ranking criteria:
         1) Level 1: Significant impact item and no further tests shall be performed until resolved. Requires a signoff prior to proceeding.
         2) Level 2: Minimal impact item that can be corrected later and does not affect continuation of testing.
   3. Part 2 - Seven (7) Day Operational Test. The Operations Test Phase shall consist of a continuous un-interrupted seven-day run period using the specified media.

D. Phase 4 Commissioning: Acceptance Test Phase:
   1. The Acceptance Test Phase shall be a test of a system or multiple systems by the Owner using the specified media, without operational or performance failure to demonstrate conformance with the performance requirements specified. The minimum duration of the Acceptance Test Phase shall be 30 days, unless otherwise specified within individual equipment specifications. This is the final test to demonstrate the facility including new and existing processes operate together as needed, intended, and specified.
      a. During this test, vary operational parameters during the day, with steady state conditions overnight.
      b. Conduct performance testing where required in individual specification sections. Where practical, coordinate timing of performance testing to fall within the nominal 30 days allocated for Acceptance Testing; however, performance testing outside of this 30-day period may be required in order to fully comply with specified performance testing requirements.
      c. The Acceptance Test Phase shall be judged completed wholly at the discretion of the Engineer with input from the Construction Manager.
      d. This test may last significantly longer than the specified calendar days listed if deficiencies are found, and the test is restarted one or more times. The Contractor shall coordinate with the Owner and provide support as necessary.
      e. After satisfactory completion the facility shall be placed into normal operation.
      f. Provide documentation of successful performance testing where required in individual equipment specifications.
      g. Provide Manufacturer's Certificates of Proper Operation.

E. Optimization Testing:
   1. Provide optimization testing as required in individual equipment specifications.

3.06 RETESTS

A. If any portion of a test does not pass, the Contractor shall correct the problem in a timely manner and repeat the test until it passes to the satisfaction of the Engineer and Owner.
   1. Functional testing of equipment or a system shall be considered complete when, in opinion of the Engineer and Construction Manager, the system, facility, or designated portion has operated in manner intended for (7) continuous days without significant interruption, unless otherwise agreed upon.
   2. Operational testing of the system, the entire facility or any portion thereof shall be considered complete when, in opinion of the Engineer and Construction Manager, the system, facility, or designated portion has operated in manner intended for (28) continuous days without significant interruption, unless otherwise agreed upon.

3. Significant Interruption: May include any of the following events:
    a. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
    b. Failure of any critical equipment or unit process that is not satisfactorily corrected within 6 hours after failure.
    c. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 24 hours after failure.
4. Operational testing of the system, the entire facility or any portion thereof shall be considered complete when, in opinion of the Engineer and Construction Manager, the system, all specified testing has been successfully completed, and all deficiencies have been corrected.

B. If a failure of any component or system occurs during any phase of commissioning, the entire phase shall be re-started. If the Commissioning Manager determines that the failure is minor and recommends continuation of the test rather than re-starting, then the Commissioning Manager shall request continuation in writing to the Construction Manager and Engineer, who, if in agreement, may permit continuation of testing.

C. If a failure of any component should occur during any phase of commissioning, the Contractor shall be responsible for the actual cost of any idle time due to such failure. Such costs of idle time shall include personnel costs of Owner's, Construction Manager's, and Engineer's staff who are assigned to coordinate, assist and witness the commissioning activities. This includes personnel costs, rental costs of equipment and any other incidental costs of the delay.

3.07 AFTER TESTS

A. Once testing has been completed, and until the Construction Manager has issued a certificate of Final Completion, all equipment shall be rechecked once by the Contractor (or more often if specified) for proper alignment and realigned, if necessary. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the Construction Manager. All equipment or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled, inspected and shall then be repaired or removed from the Site and replaced at no cost to the Owner.

END OF SECTION

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SECTION 01 99 90

REFERENCE FORMS

PART 1 FORMS

1.01 DESCRIPTION

A. The forms listed below and included in this section are referenced from other sections of the project manual:

Form No.	Title
01 33 00-A	Submittal Transmittal Form
01 45 20-A	Equipment Test Report Form
01 78 23-A	Operation and Maintenance Transmittal Form
01 78 23-B	Equipment Record Form
01 78 23-C	Equipment Record Form
09 96 00-A	Coating System Quality Control Checklist
26 05 00-A	Wire and Cable Resistance Test Data Form
26 05 00-B	Installed Motor Test Data Form
26 05 00-C	Dry Transformer Test Data Form
26 05 00-D	Motor Control Center Test Form
26 05 00-E	Medium Voltage Motor Starter Test Form
26 05 00-F	Medium Voltage Switchgear Test Form
26 05 00-G	Protective Relay Test Form
26 05 00-H	Low Voltage Switchgear Test Form
26 05 00-I	Medium Voltage Load Interrupter Switch Test Form
26 05 00-J	Liquid-Filled Transformer Test Form
26 05 00-K	Automatic Transfer Switch Test Form
26 05 00-L	Neutral Grounding Resistor Test
40 61 13-A	Loop Wiring and Insulation Resistance Test Data Form
40 61 13-B	Control Circuit Piping Leak Test Form
40 61 13-C	Controller Calibration Test Data Form
40 61 13-D	Panel Indicator Calibration Test Data Form
40 61 13-E	Recorder Calibration Test Data Form
40 61 13-F	Signal Trip Calibration Test Data Form
40 61 13-G	Field Switch Calibration Test Data Form
40 61 13-H	Transmitter Calibration Test Data Form
40 61 13-I	Miscellaneous Instrument Calibration Test Data Form
40 61 13-J	Individual Loop Test Data Form
40 61 13-K	Loop Commissioning Test Data Form
43 05 11-A	Manufacturer's Installation Certification Form
43 05 11-B	Manufacturer's Instruction Certification Form
43 05 11-C	Unit Responsibility Certification Form
43 05 13-A	Rigid Equipment Mount Installation Inspection Checklist
43 05 21-A	Motor Data Form

01 33 00-A. SUBMITTAL TRANSMITTAL FORM

Submittal Transmittal

Submittal Description:	Submittal No:[1]	Spec Section:

	Routing	Sent	Received
Owner:	Contractor/CM		
Project:	CM/Engineer		
	Engineer/CM		
Contractor:	CM/Contractor		

We are sending you:
☐ Attached
☐ Under separate cover via _____
☐ Submittals for review and comment
☐ Product data for information only
Remarks: _____

Item	Copies	Date	Section No.	Description	Review action[a]	Reviewer initials	Review comments attached

[a]*Note: NET = No exceptions taken; MCN = Make corrections noted; A&R = Amend and resubmit; R = Rejected*
Attach additional sheets if necessary.

Contractor

Certify either a or b:

a. ☐ We have verified that the material or equipment contained in this submittal meets all the requirements, including coordination with all related work, specified (no exceptions).

b. ☐ We have verified that the material or equipment contained in this submittal meets all the requirements specified except for the attached deviations.

No.	Deviation

Certified by: _____

Contractor's Signature: _____

[1]See *Section 01 33 00-1.04. A, Transmittal Procedure.*

01 45 20-A. EQUIPMENT TEST REPORT FORM

NOTE: This example equipment test report is provided for the benefit of the Contractor and is not specific to any piece of equipment to be installed as a part of this project. The example is furnished as a means of illustrating the level of detail required for the preparation of equipment test report forms for this project.

City Of Sample

Example Water Treatment Plant

Stage IV Expansion Project

ABC Construction Company, Inc., General Contractor
XYZ Engineering, Inc., Construction Manager

Equipment Test Report

- Equipment Name: Sludge Pump 2
- Equipment Number: P25202
- Specification Ref: 11390
- Location: East Sedimentation Basin Gallery

	Contractor		Construction Manager	
	Verified	Date	Verified	Date
A. Preoperational Checklist				
1. Mechanical				
a. Lubrication				
b. Alignment				
c. Anchor bolts				
d. Seal water system operational				
e. Equipment rotates freely				
f. Safety guards				
g. Valves operational				
h. Hopper purge systems operational				
i. Sedimentation tank/hopper clean				
j. O&M manual information complete				
k. Manufacturer's installation certificate complete				
2. Electrical (circuit ring-out and high-pot tests)				
a. Circuits:				
1) Power to MCC 5				
2) Control to HOA				
3) Indicators at MCC:				
a) Red (running)				
b) Green (power)				
c) Amber (auto)				
4) Indicators at local control panel				
b. Wiring labels complete				
c. Nameplates:				
1) MCC				
2) Control station				
3) Control panel				

	Contractor		Construction Manager	
	Verified	Date	Verified	Date
d. Equipment bumped for rotation				
3. Piping Systems				
a. Cleaned and flushed:				
1) Suction				
2) Discharge				
b. Pressure tests				
c. Temporary piping screens in place				
4. Instrumentation and Controls				
a. Flowmeter FE2502F calibration				
1) Calibration Report No.				
b. Flow recorder FR2502G calibrated against transmitter				
c. VFD speed indicator calibrated against independent reference				
d. Discharge overpressure shutdown switch calibration				
e. Simulate discharge overpressure Shutdown				
B. Functional Tests				
1. Mechanical				
a. Motor operation temperature satisfactory				
b. Pump operating temperature satisfactory				
c. Unusual noise, etc?				
d. Pump operation: 75 gpm/50 psig				
(1) Measurement:				
(a) Flow:				
(b) Pressure:				
(c) Test gage number:				
e. Alignment hot				
f. Dowelled in				
g. Remarks:				
2. Electrical				
a. Local switch function:				
1) Runs in HAND				
2) No control power in OFF				
3) Timer control in AUTO				
b. Overpressure protection switch PS2502C functional in both HAND and AUTO				
c. Overpressure protection switch PS2502C set at 75 psig				
d. PLC 2500 set at 24-hour cycle, 25 min ON				
C. Operational Test				
1. 48-hour continuous test. Pump cycles as specified, indicators functional, controls functional, pump maintains capacity, overpressure protection remains functional, hour meter functional				

RECOMMENDED FOR BENEFICIAL OCCUPANCY:

Construction Manager	Date

ACCEPTED FOR BENEFICIAL OCCUPANCY

Owner's Representative	Date

01 78 23-A. OPERATION AND MAINTENANCE TRANSMITTAL FORM

Date:	Submittal No:[2]
To:	Contract No:
	Spec. Section:
	Submittal Description:
Attention:	From:

Checklist	Contractor		Construction Manager	
	Satisfactory	N/A	Accept	Deficient
1. Table of contents				
2. Equipment record forms				
3. Manufacturer information				
4. Vendor information				
5. Safety precautions				
6. Operator prestart				
7. Start-up, shutdown, and postshutdown procedures				
8. Normal operations				
9. Emergency operations				
10. Operator service requirements				
11. Environmental conditions				
12. Lubrication data				
13. Preventive maintenance plan and schedule				
14. Troubleshooting guides and diagnostic techniques				
15. Wiring diagrams and control diagrams				
16. Maintenance and repair procedures				
17. Removal and replacement instructions				
18. Spare parts and supply list				
19. Corrective maintenance man-hours				
20. Parts identification				
21. Warranty information				
22. Personnel training requirements				
23. Testing equipment and special tool information				

Remarks:

Contractor's Signature :

[2] See Section 01 33 00-1.04.A, Transmittal Procedure.

01 78 23-B. EQUIPMENT RECORD FORM

Equip Descrip		Equip Loc	
Equip No.	Shop Dwg No.	Date Inst	Cost
Mfgr		Mfgr Contact	
Mfgr Address			Phone
Vendor		Vendor Contact	
Vendor Address			Phone

Maintenance Requirements	D	W	M	Q	S	A	Hours

Lubricants: Recommended:

Alternative:

Misc. Notes:

Recommended Spare Parts					Electrical Nameplate Data			
Part No	Quan	Part Name	Cost		Equip			
					Make			
					Serial No.		Id No.	
					Model No.		Frame No.	
					Hp	V	Amp	Hz
					Ph	Rpm	Sf	Duty
					Code	Insl. Cl	Des	Type
					Nema Des	C Amb	Temp Rise	Rating
					Misc.			
					Mechanical Nameplate Data			
					Equip			
					Make			
					Serial No.		Id No.	
					Model No.		Frame No.	
					Hp	Rpm	Cap	Size
					Tdh	Imp Sz	Belt No.	Cfm
					Psi	Assy No.	Case No.	
					Misc			

01 78 23-C. EQUIPMENT RECORD FORM

Equip Descrip		Equip Loc	
Equip No.	Shop Dwg No.	Date Inst	Cost
Mfgr		Mfgr Contact	
Mfgr Address			Phone
Vendor		Vendor Contact	
Vendor Address			Phone

Maintenance Requirements	D	W	M	Q	S	A	Hours

09 90 00-A COATING SYSTEM INSPECTION CHECKLIST

Project Name			
Owner		Coating System Manufacturer (CSM)	
General Contractor (GC)		Coating System Applicator (CSA)	
Area or Structure		Location within Structure	
Coating System (eg E-1)		Coating Type (eg Epoxy, etc.)	

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
1	Completion of cleaning and substrate decontamination prior to abrasive blast cleaning.	GC QC			
		CSM QC			
		CSA QC			
2	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	GC QC			
		CSM QC			
		CSA QC			
3	Completion of ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	GC QC			
		CSM QC			
		CSA QC			
4	Completion of Surface Preparation for Substrates to Be Coated.	GC QC			
		CSM QC			
		CSA QC			
5	Completion of Primer Application.	GC QC			
		CSM QC			
		CSA QC			
6	Completion of Concrete Repairs If Required and Related Surface Preparation Rework Prior to Coating System Application.	GC QC			
		CSM QC			
		CSA QC			
7	Completion of Concrete Filler/ Surface Application to Concrete.	GC QC			
		CSM QC			
		CSA QC			
8	Completion of First Finish Coat Application and of Detail Treatment at Transitions or Terminations.	GC QC			
		CSM QC			
		CSA QC			

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
9	Completion of Second Finish Coat Application and of Detail Treatment at Transitions and Terminations.	GC QC			
		CSM QC			
		CSA QC			
10	Completion of Full and Proper Cure of Coating System.	GC QC			
		CSM QC			
		CSA QC			
11	Completion of Testing of Cured Coating System including Adhesion, Holiday (Continuity) Testing and Dry Film Thickness.	GC QC			
		CSM QC			
		CSA QC			
12	Completion of Localized Repairs to Coating System Following Testing.	GC QC			
		CSM QC			
		CSA QC			
13	Final Acceptance of Coating System Installation Including Final Clean-Up Complying with Specification Requirements and the CSM's Quality Requirements.	GC QC			
		CSM QC			
		CSA QC			

26 05 00-A. WIRE AND CABLE RESISTANCE TEST DATA FORM

Wire or Cable No.:_____ Temperature, °F: _____

Location of Test	Insulation resistance, megohms
1.	
2.	
3.	
4.	
5.	
6.	
7.	

.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-B. INSTALLED MOTOR TEST DATA FORM

Motor Equipment Number: _____ Date of test: _____

Equipment Driven: _____

MCC Location: _____

						Ambient temp	°F
Resistance:							
Insulation resistance phase-to-ground megohms:							
Phase A		Phase B		Phase C			
Current at Full Load:							
Phase				Current, amps			
Phase				Current, amps			
Phase				Current, amps			
Thermal Overload Device:		Manufacturer/catalog #			Amperes		
Circuit breaker (MCP) setting:							

Motor Nameplate Markings:

Mfr		Mfr Model		Frame		HP	
Volts		Phase		RPM		Service factor**	
Amps		Freq		Ambient temp rating			°C
Time rating				Design letter**			
	(NEMA 1-10.35)				(NEMA MG-1.16)		
Code letter				Insulation class			

**Required for 3-phase squirrel cage induction motors only.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-C. DRY TRANSFORMER TEST DATA FORM

(Note: Use Data Form for dry type transformers with voltage rating of 600 Vac or less and sizes to 167 kVA single phase and 500 kVA three phase. Use NETA Test Forms and Test Procedures for higher voltages and larger transformers.)

Equipment Tag No.: _____ Temperature Rating: _____

Description/Location: _____ Feeder size/Source: _____

Primary Voltage: _____ Secondary Voltage: _____ Winding Connection: _____

A. VISUAL INSPECTION

Transformer Inspection	Pass	Fail	Note
1. Nameplate data as specified			
2. Mechanical condition			
a. Free of dents and scratches			
b. Anchored properly			
c. Shipping brackets removed			
d. Spacing from wall per nameplate			
3. Grounding *			
a. Equipment grounding			
b. System grounding			

B. INSULATION-RESISTANCE TESTS:

Perform tests with calibrated megohmeter. Apply 1000 Vdc test voltage for 60 seconds and record readings in megohms at 30-seconds and 60-seconds intervals.

Test Group	Resistance between		30-second reading	60-second reading	Absorption Ratio Index 60-sec. / 30-sec.
Primary Winding to ground	A	GRD			
	B	GRD			
	C	GRD			
Secondary Winding to ground with * N-G Bond removed	a	GRD			
	b	GRD			
	c	GRD			
Primary Winding to Secondary Winding	A	a			
	B	b			
	C	c			

Submit resistance readings to the Construction Manager immediately after the tests that are less than the manufacturer's recommended value or less than 10-megohms. Record the Absorption Ratio Index values for future reference. Ratio must be 1.0 or greater, with infinity (∞) equal to 1.0.

Contractor Representative Certified: _____ Date _____

Owner Representative Witnessed:_____ Date _____

26 05 00-D. MOTOR CONTROL CENTER TEST FORM

Equipment No.: _____ Ambient room temperature: _____

Location: _____

A. MECHANICAL CHECK:

All bolted connections either bus to bus or cable to bus shall be torqued to the manufacturer's recommendations.

B. ELECTRICAL TESTS:

1. Measure insulation resistance of each bus section phase to phase and phase to ground for 1 minute using a megohmmeter at 1000 volts.

Test results (megohms)			
Phase		Phase	
A-GRD		A-B	
B-GRD		B-C	
C-GRD		C-A	

2. Set the circuit breaker in the starter unit to comply with the requirements of NEC, Article 430-52 and Table 430-152.

3. Motor overload heater elements shall be sized and installed based on the actual nameplate full load amperes of the motor connected to the starter.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-E. MEDIUM VOLTAGE MOTOR STARTER TEST FORM

Equipment No.: _____

Location: _____

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms)

Phase:	A		B		C	

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase	A		B		C		
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

3. Perform minimum pickup voltage tests on trip and close coils.
4. Motor RTDs shall be tested by using a hot oil bath. The temperature at which the sensor trips shall be recorded for each RTD.
5. The Contactor shall be tripped by operation of each protective device.

26 05 00-F. MEDIUM VOLTAGE SWITCHGEAR TEST FORM

Equipment No.: _____

Location: _____

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms).

Phase:	A		B		C	

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase	A		B		C		
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

3. Perform minimum pickup voltage tests on trip and close coils.
4. Verify the instrument transformer ratios. Check the transformer's polarity electrically.
5. The Contactor shall be tripped by operation of each protective device.

26 05 00-G. PROTECTIVE RELAY TEST FORM

Location: _____

Switchgear Breaker No.: _____

Protective Relay Description: _____

The protective relays shall be tested in the following manner:

1. Each protective relay circuit shall have its insulation resistance tested to ground.
2. Perform the following tests on the specified relay setting:
    a. Pickup parameters on each operating element.
    b Timing test shall be performed at three points on the time dial curve.
    c. Pickup target and seal-in units.

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-1.05 Corrosive Areas.

26 05 00-H. LOW VOLTAGE SWITCHGEAR TEST FORM

Equipment No.: _____

Location: _____

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms).

Phase:	A		B		C	

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase	A		B		C		
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

3. Minimum pickup current shall be determined by primary current injection.
4. Long time delay shall be determined by primary injection at three hundred percent (300%) pickup current.
5. Short time pickup and time delay shall be determined by primary injection of current.
6. Instantaneous pickup current shall be determined by primary injection.
7. Trip unit reset characteristics shall be verified.
8. Auxiliary protective devices, such as ground fault or under voltage relays, shall be activated to ensure operation of shunt trip devices.

26 05 00-I. MEDIUM VOLTAGE LOAD INTERRUPTER SWITCH TEST FORM

Equipment Number: _____

Location: _____

Date: _____

1. Measure switch blade resistance (micro-ohms).

Phase:	A		B		C	

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase	A		B		C		
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-J. LIQUID-FILLED TRANSFORMER TEST FORM

Equipment Number: _____

Location: _____

Date/Weather Conditions: _____

A. Perform the "Insulation-Resistance Test" and "Dielectric Absorption Test" using Form 26 05 00-C, Dry Transformer Test Data Form.

B. Perform an applied voltage (low frequency dielectric) test in accordance with ANSI C57.12.90, paragraph 10.5, Applied Voltage Test. Applied voltage levels shall be 75 percent of recommended factory test levels or recommended test levels of ANSI C57.12.00, Table 5.

C. Insulating oil shall be sampled and shall be laboratory tested for the following:

1. Dielectric strength.
2. Acid neutralization.
3. Interfacial tension.
4. Color.
5. Power factor.

D. Perform a turns ratio test between the windings for all tap positions.

E. The temperature and pressure switches shall be tested using a hot oil bath and air pump.

F. The results shall be recorded and signed by the Contractor and Construction Manager. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data. Any readings which are abnormal to ANSI industry standards shall be reported to the Construction Manager.

26 05 00-K. AUTOMATIC TRANSFER SWITCH TEST FORM

Equipment Number: _____

Location: _____

Date: _____

1. Perform an insulation resistance test (1000 volts DC for 1 minute):

Phase	A		B		C		
Pole to ground							megohms
Pole to pole	AB		BC		CA		megohms

2. Perform the following operations and initial:
   a. Manual transfer _____
   b. Loss of normal power; __sec delay
   c. Return to normal power; _____sec delay

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-L. NEUTRAL GROUNDING RESISTOR TEST

Equipment No.: _____

Location: _____

The pickup and time delay setting on the ground fault relay shall be set in accordance with Section 26 05 74.

1. The transformer neutral insulation resistance shall be measured with and without the grounding resistor connected to insure no parallel ground paths exist.
2. The protective relay pickup current shall be determined by injecting test current into the current sensor. The pickup current should be within 10 percent of the dial setting. Record the dial setting and actual pickup tie.
3. The relay timing shall be tested by injecting 150 and 300 percent of pickup current into the current sensor. The relay timing shall be in accordance with the manufacturer's published time-current characteristic curves. Record the relay timing at 150 and 300 percent of pickup current.
4. The circuit interrupting device shall be operated by operating the relay.

The results shall be recorded and signed by the Contractor and Construction Manager. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data.

40 61 13-A. LOOP WIRING AND INSULATION RESISTANCE TEST DATA FORM

Loop No.: _____

List all wiring associated with a loop in table below. Make applicable measurements as indicated after disconnecting wiring.

Wire No.	Panel Tie	Field TB	Continuity Resistance[a]		Insulation Resistance[b]			
			Cond./ Cond.	Cond./ Shield	Shield/ Gnd.	Shield/ Cond.	Cond./ Gnd.	Shield/ Shield
A			--	(A/SH)				
B			(A/B)	--				
C			(A/C)	--				
D			(A/D)	--				
etc.								

NOTES:

a. Continuity Test. Connect ohmmeter leads between wires A and B and jumper opposite ends together. Record resistance in table. Repeat procedure between A and C, A and D, etc. Any deviation of ±2 ohms between any reading and the average of a particular run indicates a poor conductor, and corrective action shall be taken before continuing with the loop test.

b. Insulation Test. Connect one end of a 500 volt megger to the panel ground bus and the other sequentially to each completely disconnected wire and shield. Test the insulation resistance and record each reading.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-B. CONTROL CIRCUIT PIPING LEAK TEST FORM

Loop No.:_____

List tubing associated with loop in table below. Make applicable measurements after isolating any air consuming pilots from circuit.

Tube No.	Tubing Equivalent Length of 1/4-Inch Copper[a]	Test Period (seconds)	Permitted Pressure Drop (psi)[b]	Measured Pressure Drop (psi)
A				
B				
C				
D				
etc.				

NOTES:

a. Convert actual tubing and air motor volume to equivalent 1/4-inch copper tubing.

b. Pressure drop shall not exceed 1 psi per hundred feet 1/4-inch tubing per 5 seconds.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-C. CONTROLLER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____ Process Variable (PV) Scale: _____

Output: _____ Output Scale: _____

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

Connect output to PV for following tests:

Set Point (SP) Indicator Accuracy			Output Meter Accuracy			Controller Accuracy		
SP	PV Reading	Expected % Dev.	Actual Reading	Expected Reading	Actual % Dev.	OUTPUT	OUTPUT	% Dev.
(0%)								
(50%)								
(100%)								
% Deviation Allowed:			% Deviation Allowed:			% Deviation Allowed:		

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-D. PANEL INDICATOR CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Scale: _____ Range: _____

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-E. RECORDER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____ Chart: _____

Scale: _____ Range: _____

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-F. SIGNAL TRIP CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Scale: _____ Range: _____

Set Point(s): _____

After setting set point(s), run signal input through entire range and calculate deadband.

Set Point	Incr. Input Trip Point	Decr. Input Trip Point	Calc. Deadband	Required Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-G. FIELD SWITCH CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No: _____

Input: _____

Range: _____

Set Point(s): _____

Simulate process variable (flow, pressure, temperature, etc.) and set desired set point(s). Run through entire range of switch and calculate deadband.

Set Point	Incr. Input Trip Point	Decr. Input Trip Point	Calc. Deadband	Required Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-H. TRANSMITTER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Output: _____

Range: _____ Scale: _____

Simulate process variable (flow, pressure, temperature, etc.) and measure output with appropriate meter.

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-I. MISCELLANEOUS INSTRUMENT CALIBRATION TEST DATA FORM

(For instruments not covered by any of the preceding test forms, the Contractor shall create a form containing all necessary information and calibration procedures.)

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-J. INDIVIDUAL LOOP TEST DATA FORM

Loop No.: _____

Description: (Give complete description of loop's function using tag numbers where appropriate.)

P&ID No.: (Attach copy of P&ID.)

a. Wiring tested:

(Attach test form 40 61 13-A)

b. Instrumentation tubing/piping tested:

(Attach test form 40 61 13-B)

c. Instruments calibrated:

(Attach test forms 40 61 13-C through I)

d. List step-by-step procedures for testing loop parameters. Test loop with instruments, including transmitters and control valves, connected and functioning. If it is not possible to produce a real process variable, then a simulated signal may be used with the Construction Manager's approval.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-K. LOOP COMMISSIONING TEST DATA FORM

Loop No.: _____

a. Loop tested:

(Attach test form 40 61 13-J)

b. Controlled or connected equipment tests confirmed:

c. Give complete description of loop's interface with process.

d. With associated equipment and process in operation, provide annotated chart trace of loop response to changes in set points for verification of performance. This chart should demonstrate 1/4-amplitude damping as output adjusts to set point change. Show set points, starting and finishing times on chart, as well as any other pertinent data.

Connect 2-pen recorder to process variable (PV) and to controller output. Use 1 inch/second chart speed.

Pen 1 - PV - Connections:

Pen 2 - Output - Connections:

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

43 05 11-A. MANUFACTURER'S INSTALLATION CERTIFICATION FORM

Contract No:	Specification section:
Equipment name:	
Contractor:	
Manufacturer of equipment item:	

The undersigned manufacturer of the equipment item described above hereby certifies that he has checked the installation of the equipment and that the equipment, as specified in the project manual, has been provided in accordance with the manufacturer's recommendations, and that the trial operation of the equipment item has been satisfactory.

Comments:

Manufacturer	Contractor
Signature of Authorized Representative	Signature of Authorized Representative
Date	Date

43 05 11-B. MANUFACTURER'S INSTRUCTION CERTIFICATION FORM

Contract No:	Specification Section:
Equipment name:	
Contractor:	
Manufacturer of equipment item:	

The undersigned manufacturer certifies that a service engineer has instructed the wastewater treatment plant operating personnel in the proper maintenance and operation of the equipment designated herein.

Operations Check List (check appropriate spaces)	
Start-up procedure reviewed	
Shutdown procedure reviewed	
Normal operation procedure reviewed	
Others:	

Maintenance Check List (check appropriate spaces)	
Described normal oil changes (frequency)	
Described special tools required	
Described normal items to be reviewed for wear	
Described preventive maintenance instructions	
Described greasing frequency	
Others:	

Manufacturer	Signature of Contractor Representative Date
Signature of Authorized Representative	
Date	Signature of Authorized Representative Date

43 05 11-C. UNIT RESPONSIBILITY CERTIFICATION FORM

CITY CREEK WATER TREATMENT PLANT UPGRADES

CERTIFICATE OF UNIT RESPONSIBILITY

FOR SPECIFICATION SECTION _____

_____

[SECTION TITLE]

In accordance with Section 43 05 11-1.02 Unit Responsibility of the contract documents, the undersigned manufacturer of driven equipment ("manufacturer") accepts unit responsibility for all components of equipment furnished to the Project under specification Section_____ , and for related equipment manufactured under sections**_____, _____, and _____ .**

We have reviewed the requirements for sections 43 05 11 and 43 23 03 where applicable) and all sections referencing this (these) section(s), including but not limited to drivers, supports for driving and driven equipment and all other specified appurtenances to be furnished to the Project by manufacturer. And, we have further reviewed, and modified as necessary, the requirements for associated variable speed drives and motor control centers. We hereby certify that all specified components are compatible and comprise a functional unit suitable for the specified performance and design requirements whether or not the equipment was furnished by us. We will make no claim nor establish any condition that problems in operation for the product provided under this specification Section _____ are due to incompatibility of any components covered by this Certificate of Unit Responsibility. Nor will we condition or void any warranty for the performance of the product of this specification Section _____ due to incompatibility of any components covered under this Certificate of Unit Responsibility.

Our signature on this Certificate of Unit Responsibility does not obligate us to take responsibility for, nor to warrant the workmanship, quality, or performance of related equipment provided by others under specification sections _____, _____, and _____. Our obligation to warranty all equipment provided by us shall remain unaffected.

Notary Public	Name of Corporation
Commission expiration date	Address
Seal:	By:
	Duly Authorized Official
	Legal Title of Official
	Date

43 05 13-A. RIGID EQUIPMENT MOUNT INSTALLATION CHECKLIST

SLCDPU CITY CREEK TREATMENT PLANT UPGRADES BRIC PACKAGE

Equipment Tag No.: _____ Date: _____

Grout Product Name and Type: _____

Grouting System Manufacturer: _____

Grouting Application Contractor: _____

General Contractor: _____

Step 1: Verify Equipment Anchor Installation Conformance to Equipment Pad Details		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 2: Completion of Cleaning and Concrete Substrate Preparation Prior to Grouting		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 3: Equipment Leveling		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 4: Installation of Protection of Adjacent Surfaces or Structures NOT TO BE GROUTED		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 5: Preparation and Construction of Forms and Epoxy Grout Filling Standpipes		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 6: Completion of Ambient Condition Control in Structure or Building Area and Acceptance of Ambient Conditions as They Apply to Application and Curing Requirements for the Grouting System		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 7: Epoxy Grout Installation		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 8: Completion of Full and Proper Cure of Epoxy Grout		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date

Name: Grout Manufacturer's Technical Rep.		Date
Step 9: Completion of Localized Repair of Grout Voids		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 10: Final Acceptance of Grouting System Installation Including Final Clean-Up of the Work Site Complying with All Specification Requirements and the GSM's Quality Requirements		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date

43 05 21-A. MOTOR DATA FORM

Equipment Name: _____ Equipment No(s): _____

Project Site Location: _____

Nameplate Markings

Mfr:		Mfr Model:		Frame:		Horsepower:	
Volts:		Phase:		RPM:		Service Factor:	
FLA:		LRA:		Frequency:		Amb Temp Rating:	ºC

Time rating:		Design Letter:	
	(NEMA MG1-10.35)		(NEMA MG-1.16)
KVA Code Letter:		Insulation Class:	

The following information is required for explosion-proof motors only:

A. Approved by UL for installation in Class _____, Div _____, Group _____
B. UL frame temperature code ____ (NEC Tables 500-8B)

The following information is required for all motors 1/2 horsepower and larger:

A. Guaranteed minimum efficiency _____

(Section 43 05 21-2.04 Motor Efficiency)

B. Nameplate or nominal efficiency _____

Data Not Necessarily Marked on Nameplate

Type of Enclosure:			Enclosure Material:		
Temp Rise:		ºC (NEMA MG1-12.41,42)			
Space Heater included?	☐ Yes	☐ No	If Yes:	Watts	Volts
Type of motor winding over-temperature protection, if specified:					

Provide information on other motor features specified:

_____

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SECTION 02 41 00

DEMOLITION

PART 1 - GENERAL

1.01 SCOPE

A. Section includes demolition of designated structures, foundations, slabs-on-grade, sidewalks, and roadways; disconnection and demolition or capping of identified utilities; process equipment; electrical equipment; building mechanical equipment; and cleanup and removal of demolished materials from the site. Section also includes temporary construction to protect adjacent structures and property against damage and soiling, allow building occupancy, and provide safe access around demolition work. Finally, section includes protection of items to remain.

1.02 GENERAL

A. Coordination
   1. When unanticipated mechanical, electrical, or structural elements that conflict with the intended function or design are encountered, investigate and measure the nature and extent of the conflict and promptly submit written report to the Construction Manager.
   2. Demolition activities to be coordinated with Integrated Excavation Plan. Address protection and support of adjacent structures, utilities, and pipelines.

1.03 QUALITY ASSURANCE

A. Accomplish demolition without damaging or soiling existing structures, equipment, and appurtenances that are to remain.

B. Contractors Qualifications
   1. Contractor shall have a minimum of 5 years' experience in construction and similar demolition work.

1.04 SUBMITTALS

A. Drawings and Data
   1. Submit a demolition plan for review, describing proposed sequence, methods, and equipment for demolition and disposal of each item or structure prior to any demolition work commencing. Include dust, noise, and odor control measures. Provide inventories of items to be removed.
   2. Provide photographs or videotape, sufficiently detailed, of existing conditions of adjoining structures and site improvements that might be misconstrued as damage caused by selective demolition operations.
   3. Provide product data for any repair materials to Construction Manager prior to use.
   4. The Contractor shall submit a plan to the Construction Manager that describes the hazardous materials work.
   5. Contractor's Demolition Plan shall take into account all geotechnical conditions.

6. Include description of demolition by pipeline if contractor will abandon in place and fill or remove entirely. See requirements in 3.01.C.

B. Certifications
   1. The Contractor shall submit certified copies of all permits, applications and other documentation required by the regulating agency for performance, to completion, of the hazardous materials work. Submit landfill records indicating receipt and acceptance of wastes by a landfill facility licensed to accept these wastes.

C. Record Drawings
   1. Locate, identify, and mark each disconnected service and utility termination point on the project Record Drawings and As-Built Drawings.

1.05 WARRANTY

A. Existing Special Warranty
   1. Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

PART 2 - PRODUCTS

2.01 SERVICE CONDITIONS

A. The Contractor shall provide 72 hours notice to Construction Manager of any activities that will affect the public.

B. The Contractor shall maintain circulation of traffic within area at all times during demolition operations.

2.02 MATERIALS

A. Unless otherwise specified, use repair materials identical to existing materials. Where identical materials are unavailable or cannot be used for exposed surfaces, use materials that visually match adjacent surfaces to the fullest extent possible and whose installed performance equals or surpasses that of existing materials.

B. FLOWABLE FILL FOR ABANDONMENT
   1. Flowable fill for abandonment shall be Type K: CLSM. See 31 23 00 Excavation and Fill.

PART 3 - EXECUTION

3.01 PREPARATION

A. Survey Marker Reference Points
   1. Provide three reference points for each survey marker and monument removed, establish by a registered surveyor in the State of Utah and 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. Provide documentation verifying reestablishment of survey markers and monuments, signed by registered surveyor in the State of Utah.

B. Disconnection of Utility Service
   1. CONTRACTOR shall contact “Blue Stakes of Utah 811” before performing Work requiring excavation to remove or abandon existing facilities. Contractor shall be responsible to notify and coordinate with affected utility companies before starting work and comply with their requirements.
   2. Locate, identify and mark each existing service and utility to be disconnected, at the termination points. Arrange with and perform work required by utility companies for discontinuance or interruption of utility services due to demolition work. Obtain permission from utility owner before abandoning or removing any existing structures, materials, equipment and appurtenances. Verify that services and utilities are disconnected and capped prior to beginning demolition.

C. Pipe Abandonment In-Place and Demolition Removal.

For pipelines shown on Contract Drawings, Demolition Plans and identified as abandon:
   1. Abandon In-Place:
      a. Over unpaved areas: Grout and plug ends
      b. Over paved areas: Grout fill entire pipeline and seal
   2. Pipe Demolition Removal
      a. Remove pipe entirely and backfill compact per 31 23 00 Excavation and Fill
      b. Contractor may elect to remove pipes entirely in-lieu of abandonment in place.

D. CUTTING, PLUGGING, CAPPING, AND ABANDONMENT OF PIPING
   1. Do not begin cut, plug, cap, and abandonment operations until replacement process lines have been constructed, tested, and have been approved for use.
   2. Make cut and install Type K: CLSM (typ) or blind flange at locations shown on the Drawings and/or as directed by Owner or Engineer.
   3. Process piping to be abandoned shall not be valved off and shall not be cut, plugged, or capped. other than as shown on the Drawings and/or as directed by Owner or Engineer.
   4. Plug openings in abandoned process piping part of structures, a minimum plug length of 10 feet, to prevent groundwater infiltration.
   5. For abandoned lines beneath paved areas, the entire line underneath paved areas shall be plugged and filled with CLSM or concrete slurry. Fill pipe end with CLSM 8 inches beyond the end of pipe.
   6. For abandoned lines under unpaved areas plug a minimum of 10 ft on both sides.
   7. A blind flange shall be used for abandoned or demolished sections of pressurized process piping where remaining portions are to remain in service. Blind flange material and pressure rating shall be in accordance Section 40 05 01 Piping Systems.
   8. Remove and dispose of surface identifications such as cleanouts. Cleanouts shall be filled with CLSM.
   9. Remove surface identifications and appurtenances such as valve boxes.

10. Collect and dispose of excess flowable fill material utilizing the Concrete Washout Facility in accordance with contractors stormwater pollution prevention plan.

E. Protection

1. Prior to beginning work, provide suitable protection such that the Work shall not hinder or interfere with safe use of adjacent building spaces in any way, for any purpose. Passageways to, from, and between building spaces adjacent to the Work shall be maintained free and clear of obstruction and safe for normal occupancy and intended use at all times. Cap or plug pipes and other conduits abandoned due to demolition as indicated on drawings or as specified.

3.02 PERFORMANCE

A. Carefully remove materials to be reused and salvaged. Such materials shall be suitably cleaned and dismantled, moved to designated storage areas, protected from weathering, staining, construction damage, theft and vandalism, and arranged to facilitate inspection. Carefully handle, assemble, and reinstall materials to be reused, in undamaged and usable condition. Deliver material to be salvaged to the Owner as directed by Construction Manager.

B. Repair or remove items that are damaged. Repair and installation of damaged items shall be at no additional compensation and to condition at least equal to that, which existed prior to start of work. Replace materials that are damaged by the Work with suitable equivalent new materials.

C. Demolition

1. Execute the Work in a careful, orderly manner. Provide and maintain barriers, dust screens, ventilation, and warning lights as may be necessary to protect persons and property. Perform the Work with care, using tools and methods that will not transfer any heavy shocks to adjacent structures. Prevent conditions, obstructions, contamination, vibrations, or disturbances that are hazardous. Conduct the Work in a manner giving prime consideration to, but not necessarily limited by:
   a. Protection of the public, the Owners property, the Work, and of the existing adjacent structures.
   b. Protection for adverse weather.
   c. Control/prevention of unwanted sounds (noise), shocks, vibration, dirt, and dust.
   d. Provision and maintenance of safe and orderly ingress, access and egress to, within and from the Work.
   e. Coordination and cooperation with the Owner through the Construction Manager.
   f. Remove from the project site and legally dispose of the removed materials not reused and salvaged.

D. Partial Demolition

1. Remove all facilities that are scheduled for demolition to their full depth, including foundation slabs and footings, unless otherwise shown or specified for partial demolition.
2. Partial demolition includes those facilities where a portion of a structure is to remain. Partial demolition also includes the removal and disposal of all pipe, pipe hangers, mechanical equipment, equipment supports, structural attachments and supports,

and embedded items from below grade portion of facilities that will be left in place and backfilled. Limits of partial demolition are shown on the Drawings.

3. Partial demolition procedures shall not impair the integrity of the existing structure that is to remain. Where necessary, and where shown, the Contractor shall saw cut or line core drill the existing structure to prevent rupturing or cracking facilities that remain in use.
4. Those structures damaged by the Contractor that are to remain in service shall be repaired to the satisfaction of the Owner at the Contractor's expense.
5. Cut off all pipes, structural attachments, and embedded metal supports that project into the demolition area flush with the wall, floor or ceiling.
6. Remove all pipe hangers, mechanical equipment, mechanical attachments, and supports. Where necessary, empty pipes shall be plugged with fireproof sealant to maintain fire rating for wall.
7. Unless otherwise noted on the drawings where concrete removal occurs, existing reinforcing that is exposed shall be burned off at least 1 inch into the remaining concrete. All holes shall be patched with epoxy concrete to form a smooth wall or floor finish.
8. For floors and walls to be abandoned in place, provide bracing, protection, additional reinforcement, and support in coordination with the final restoration and backfill. Provide drainage relief to structure with penetrations or relief holes within the foundation floors.
9. Structural walls to be demolished or abandoned in place shall be removed entirely to a minimum of 10 feet below finish grade unless otherwise specified on drawings.

E. Debris Removal

1. Remove from the project site and legally dispose of all debris resulting from the Work. Debris shall not be accumulated.
2. Maintain the work areas free of debris and swept broom clean at all times.
3. Provide and maintain readily accessible debris containers, appropriate and suitable for the type of refuse and local work conditions, and as designated and approved by the Construction Manager.
4. Clean each active work area no less than once each workday. Empty each debris container and remove all debris from each active work area no less than once each workday, and more often as necessary to prevent obvious accumulation and hazardous conditions.

F. Salvage

1. Materials, equipment and appurtenances removed, that are not designated for relocation, shall become the property of Contractor and shall be hauled from site and disposed of at no additional cost to the Owner. However, Owner has first right of refusal on all equipment being demolished.
2. Material salvaged from this work shall not be reused, except, where reuse is specifically indicated in the Contract Documents, or when the equipment is to be turned over to the Owner for reuse.
3. Store equipment to be salvaged for relocation where directed by Construction Manager, and protect from the elements and damage during work. Other materials,

equipment and appurtenances removed and designated for salvage by the Owner shall also be stored where directed by the Construction Manager.

END OF SECTION

SECTION 03 11 00

CONCRETE FORMING

PART 1 GENERAL

1.01 DESCRIPTION

A. Formwork requirements for concrete construction.

1.02 QUALITY ASSURANCE

A. References:

1. The references listed below are part of this section. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict, the requirements of this section shall prevail.

Reference	Title
ACI 117	Tolerances for Concrete Construction and Materials
ACI 301	Specifications for Structural Concrete
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.5	Specifications for Environmental Concrete Structures
National Institute of Standards - PS1	Construction and Industrial Plywood

B. Design – General:

1. Provide design of formwork, shoring and reshoring systems by the Contractor's Professional Engineer currently registered in the State of Utah.
2. Design, engineering, and construction of formwork, shoring, and reshoring systems is the responsibility of the Contractor.
3. Develop a procedure and schedule for removal of shores (and installation of reshores).
4. Structural record calculations, signed and sealed by the Contractor's Engineer, are required to prove that all portions of the structure, in combination with the remaining forming and shoring systems, have sufficient strength to safely support their own weight plus the loads placed thereon.
5. When developing procedures, schedules, and structural calculations; consider the structural system that exists, effects of imposed loads, and the strength of concrete at each stage of construction.

C. Design Criteria:

1. Design formwork in accordance with ACI 301 and ACI 318 for building structures and ACI 350 and 350.5 for environmental structures to provide concrete finishes as specified in Section 03 30 00.
2. Design systems for full height of wet concrete pressure.
3. Design formwork to limit maximum deflection of form facing materials, as reflected in concrete surfaces exposed to view, to 1/240 of span.

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturer's product data with installation instructions:
      a. Form materials.
      b. Form ties (with waterstops).
      c. Form release compound.
      d. Void forms.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Letter of certification:
      a. Stating that formwork has been designed in accordance with this specification and referenced documents, sealed and stamped by the Contractor's registered design Engineer.

PART 2 PRODUCTS

2.01 FORMS

A. Wood Forms:
   1. Provide new and unused exterior grade plywood panels manufactured in accordance with American Plywood Association (APA) and bearing the trademark of that group.
      a. Forms for concrete surfaces exposed to view: use APA High Density Overlay (HDO) Plyform Class I Exterior 48" X 96" X 3/4".
      b. Forms for other concrete surfaces: use APA Douglas Fir B-B Plyform Class I Exterior 48" X 96" X 3/4-inch.
   2. When approved, plywood may be reused.

B. Metal Forms:
   1. Do not use aluminum. Provide forms free of rust and straight without dents to provide members of uniform thickness.

2.02 FORM TIES

A. Commercially fabricated for use in form construction. Fabricated so that ends or end fasteners can be removed without causing spalling at surfaces of the concrete. Cone on ends shall be 3/4 inch to 1 inch diameter. Provide embedded portion of tie not less than 1 1/2 inch from face of concrete after cone ends have been removed. Provide ties with integral waterstops at water-retaining and below grade structures.

B. Tapered through-bolts may be used when approved. Use 1-inch minimum diameter at the smallest end. Fill tapered tie holes after cleaning to produce watertight construction. Use a mechanical waterstop plug near the center of the wall and fill each side with non-shrink cement grout. Mechanical waterstop plug shall be Greenstreak Group, Inc. "X-Plug"; or equal.

2.03 FORM RELEASE COMPOUND

A. Coat form surfaces in contact with concrete using a non-staining, non-residual, water based, bond-breaking form coating. Use NSF approved form release agents in potable water containment structures.

PART 3 EXECUTION

3.01 PREPARATION

A. Cover surface of forms with form release compound prior to form installation in accordance with manufacturer's recommendations.

B. Do not permit excess form coating material to stand in puddles on forms or hardened concrete surfaces against which fresh concrete is to be placed.

C. Clean surfaces of forms, reinforcing steel and other embedded items of accumulated mortar, grout, or other foreign materials from previous concreting or construction activities before concrete is placed.

3.02 FORMWORK CONSTRUCTION

A. Form vertical surfaces of cast-in-place concrete including sides of footings.

B. Construct and place forms so that the resulting concrete will be of the shape, lines, dimensions, and appearance indicated on the Drawings. Brace or tie forms together to maintain position and shape under the load of freshly-placed concrete.

C. Tighten forms to prevent leakage.

D. Provide temporary openings(windows) at base of column and wall forms and at other points where necessary to facilitate cleaning and observation immediately before concrete is placed.

E. Provide temporary openings to limit height of free fall of concrete and to limit the lateral movement of concrete during placement. Openings are required in wall placements greater than 20 feet in height, spaced no more than 8 feet on center measured horizontally and vertically.

F. Place a 3/4-inch chamfer strip at exposed to view corners of formed surfaces.

G. At construction joints, overlap hardened concrete surface by at least 1 inch. Brace forms against hardened concrete to prevent movement, offsets, or loss of mortar at construction joint and to maintain a true surface. Where possible, locate juncture of built-in-place forms at architectural lines, control joints, or at other inconspicuous lines.

H. Where circular sections are formed using flat faced materials, use flat form lengths not exceeding 2 feet wide and the resulting deflection angles at the joints is not greater than 3-1/2 degrees.

I. Construct wood forms for openings to facilitate loosening. Anchor forms so that movement of any part of the formwork system is prevented during concrete placement.

J. At platforms constructed to move equipment over in-place reinforcement, provide beams, struts, and/or legs, supported directly on formwork or other structural members without resting on reinforcing steel.

K. Provide a positive means of adjustment (wedges or jacks) at shores and struts to take up settlement during concrete placement. Brace forms against lateral deflection. Fasten in-place wedges and shims used for final adjustment of forms prior to concrete placement.

L. Place tapered through-bolt form ties with the larger end on the side of the structure in contact with liquid.

3.03 TOLERANCES

A. Install formwork with tolerances in accordance with ACI 117 and the following (the more stringent requirement controls):

1. Install formwork in accordance with manufacturer's written instructions.
2. Vertical surface tolerance from plumb; walls, columns, piers, and risers:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 10 feet of height
3. Vertical surface tolerance from plumb; exposed wall corners, end columns, control-joint grooves, and other exposed to view vertical lines:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 20 feet of height
4. Horizontal variation from level or from grade; top of slabs, slab soffits, ceilings, and beam soffits, measured before removal of supporting shores:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
   ± 1/4 inch in any 10 feet of length
5. Horizontal variation from level or from grade; exposed lintels, sills, parapets, horizontal grooves, and other exposed-to-view horizontal lines:
   ± 1/2 inch for entire length
   ± 1/4 inch in any 20 feet of length.
6. Plan position variation; columns, walls, and partitions:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
7. Plan location and size; sleeves, floor openings, walls, wall openings, beams, and columns:
   ± 1/2 inch
8. Cross sectional dimensions; columns and beams and thickness of slabs and walls:
   ± 3/8 inch
9. Plan dimensions; footings and foundations:
   minus 1/2 inch
   + 2 inches
10. Misplacement or eccentricity; footings and foundations:
    2 percent of footing width in direction of misplacement not more than 2 inches

11. Thickness; footings and foundations:

    minus 5 percent

    no limit on the maximum increase except that which may interfere with other construction.

12. Step variance in flight of stairs:

    Rise $\pm$ 1/16 inch

    Tread from level $\pm$ 1/8 inch

B. Use control points and benchmarks for reference purposes to check tolerances. Establish and maintain reference points in an undisturbed condition until final completion and acceptance of the work.

C. Regardless of tolerances listed, no portion of a structure shall extend beyond the legal boundary of work site.

D. Camber formwork to compensate for anticipated deflections in formwork under wet load of concrete. Adjust camber to maintain above specified tolerances in hardened concrete after forms and shoring are removed.

3.04 REMOVAL OF FORMS

A. Do not impose construction loads or remove shoring from any part of the structure until that portion of the structure in combination with remaining forming and shoring systems has sufficient strength to safely support its weight and loads placed thereon.

B. If forms are loosened and not removed, proceed same day with wet curing operations to soak surfaces of concrete where forms are loosened. When wet curing is not practical or not planned, loosen, remove, and start approved curing procedures on the same day.

C. When required for concrete curing in hot weather, required for repair of surface defects, or when required for finishing at an early age; remove forms as soon as concrete has hardened sufficiently to resist damage from removal operations or lack of support.

D. Remove top forms on sloping surfaces as soon as concrete has attained sufficient stiffness to prevent sagging. Make repairs or finishing treatment on such sloping surfaces immediately after form removal.

E. Remove wood forms for wall openings as soon as this can be accomplished without damage to concrete.

F. Remove formwork from columns, walls, sides of beams, and other parts not supporting weight of concrete as soon as concrete has hardened sufficiently to resist damage from removal.

G. When shores and supports are so arranged such that non-load-carrying form facing material can be removed without loosening or disturbing other shores and supports, facing material may be removed when concrete has sufficiently hardened to resist damage from removal.

H. In all cases, proceed with curing same day as form removal.

I. Where no reshoring is planned, forms and shoring used to support weight of concrete shall be left in place until concrete has attained its specified 28-day compressive strength.

3.05 RESHORING

A. Do not impose construction loads or remove shoring from any part of the structure until that portion of the structure, in combination with remaining forming and shoring systems, has sufficient strength to safely support its weight and loads placed thereon.

B. While reshoring is underway, no superimposed dead or live loads are permitted on the new construction.

C. During reshoring, do not subject concrete in structural members to combined dead and construction loads in excess of loads that the structural members can adequately support.

D. Place reshores as soon as practicable after stripping operations are complete, but in no case later than the end of working day on which stripping occurs.

E. Place reshores to carry their required loads without overstressing.

F. Where a reshoring procedure is planned, supporting formwork may be removed when concrete has reached the concrete strength specified by the formwork engineer's structural calculations and verified by field cured test cylinders or other approved method.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Reinforcing steel for use in reinforced concrete.

1.02 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements For Structural Concrete
ACI SP-66	ACI Detailing Manual
ASTM A615	Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Epoxy-Coated Steel Reinforcing Bars
ASTM A884	Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A1064	Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
AWS D1.4	Structural Welding Code - Reinforcing Steel
CRSI-PRB	Placing Reinforcing Bars
CRSI-MSP	Manual of Standard Practice
FEDSPEC QQ-W-461H	Wire, Steel, Carbon (Round, Bare, and Coated)

1.03 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

4. Mill certificates of mill analysis, tensile, and bend tests for all reinforcing.
5. Manufacturer and type of proprietary reinforcing steel splices. Submit a current ICC Report and manufacturer's literature that contains instructions and recommendations for each type of coupler used.
6. Qualifications of welding operators, welding processes and procedures.
7. Reinforcing steel shop drawings showing reinforcing steel bar quantities, sizes, spacing, dimensions, configurations, locations, mark numbers, lap splice lengths and locations, concrete cover and reinforcing steel supports. Reinforcing steel shop drawings shall be of sufficient detail to permit installation of reinforcing steel without reference to the contract drawings. Shop drawings shall not be prepared by reproducing the plans and details indicated on the contract drawings but shall consist of completely redrawn plans and details as necessary to indicate complete fabrication and installation of reinforcing steel, including large scale drawings at joints detailing bar placement in congested areas. Placement drawings shall be in accordance with ACI 315. Reinforcing details shall be in accordance with ACI SP-66.

1.04 DELIVERY, STORAGE AND HANDLING

A. Ship reinforcing steel to the jobsite with attached plastic or metal tags having permanent mark numbers which match the shop drawing mark numbers. All reinforcing shall be supported and stored above ground. Use only plastic tags secured to the reinforcing steel bars with nylon or plastic tags for epoxy coated reinforcing steel bars.

PART 2 PRODUCTS

2.01 BAR REINFORCEMENT

A. Reinforcing steel bars shall be deformed billet steel in conformance with ASTM A615, Grade 60. Bars to be welded shall be deformed billet steel conforming to ASTM A706. Where specified, reinforcing steel shall be epoxy-coated in conformance with ASTM A775.

B. Reinforcing steel bars in structural elements designated on the design drawings as "concrete shear walls" shall be ASTM A706. ASTM A615 Grade 60 reinforcement may be used if the following requirements are met:
   1. The actual yield strength based on mill tests does not exceed the specified yield strength by more than 18,000 psi.
   2. The ratio of the actual tensile strength to the actual yield strength is not less than 1.25.

C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.02 WIRE FABRIC

A. Wire fabric shall be welded steel mesh conforming to ASTM A1064.

2.03 WIRE AND PLAIN BARS

A. Wire used as reinforcement and bars used as spiral reinforcement in structures shall be cold drawn steel conforming to ASTM A1064.

2.04 SMOOTH DOWEL BARS

A. Smooth dowel bars shall conform to ASTM A615, Grade 60, with a metal end cap at the greased or sliding end to allow longitudinal movement.

2.05 EPOXY COATED BARS

A. Epoxy coated bars shall conform to ASTM A775 and ASTM A884.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.06 EPOXY COATED REINFORCING STEEL BAR PATCHING MATERIAL

A. Epoxy coated reinforcing steel bar patching material shall be compatible with coating material, inert in concrete, obtained from manufacturer of the epoxy resin used to coat the reinforcing steel bars and meet the requirements of ASTM A775.

2.07 REINFORCING STEEL MECHANICAL SPLICES

A. Reinforcing steel mechanical splices shall be a positive connecting threaded type mechanical splice system manufactured by Erico, Inc., Dayton Superior, Williams Form Engineering Company, or approved equal.

B. Type 1 mechanical splices shall develop in tension or compression a strength of not less than 125 percent of the ASTM specified minimum yield strength of the reinforcement and shall meet all other ACI 318 requirements. Where splices at the face of wall are shown or approved, form saver-type mechanical couplers may be used. Form-saver couplers shall have integral plates designed to positively connect coupler to formwork. Type 1 mechanical splices are typical except for locations noted below where Type 2 mechanical splices are required.

C. Type 2 mechanical splices shall meet the requirements for a Type 1 mechanical splice, plus develop the ASTM specified tensile strength of the reinforcement. Type 2 mechanical splices shall be provided at locations specifically noted on the design drawings.

2.08 TIE WIRE

A. The wire shall be minimum 16 gage annealed steel conforming to FEDSPEC QQ-W-461H.

2.09 BAR SUPPORTS

A. Bar supports coming into contact with forms shall be CRSI Class 1 plastic protected or Class 2 stainless steel protected and shall be located in accordance with CRSI-MSP and placed in accordance with CRSI-PRB. Plastic coating on legs shall extend at least 0.5-inch upward from form surface.

B. Provide precast concrete blocks, four inches square in plan, with embedded tie wires (wire dobies) as specified by CRSI 1 MSP for footing and slabs on grade. Do not use brick, broken concrete masonry units, spalls, rocks, construction debris, or similar material for supporting reinforcing steel. Precast concrete blocks shall have same or higher compressive strength as specified for concrete in which they are located.

C. Provide stainless steel or plastic protected plain steel supports for other work.

2.10 FABRICATION:

A. Fabricate reinforcing steel bars in accordance with ACI 315 and the following tolerances:
   1. Sheared lengths: +/-1 inch.
   2. Overall dimensions of stirrups, ties, and spirals: +/-1/2 inch.
   3. All other bends: +0 inch, -1/2 inch
   4. Minimum diameter of bends of reinforcing steel bars: Per ACI 318.

PART 3 EXECUTION

3.01 PLACEMENT TOLERANCE

A. Reinforcing steel placement tolerance shall conform to the requirements of ACI 117, ACI 318, and the following:
   1. Reinforcing steel bar clear distance to formed surfaces shall be within +/-1/4 inch of specified clearance and minimum spacing between bars shall be a maximum of 1/4 inch less than specified.
   2. Reinforcing steel top bars in slabs and beams shall be placed +/-1/4 inch of specified depth in members 8 inches deep or less and -1/4", +1/2 inch of specified depth in members greater than 8 inches deep.
   3. Reinforcing steel spacing shall be placed within +/- one bar diameter or +/- 1 inch, whichever is greater.
   4. The minimum clear distance between reinforcing steel bars shall be equal to the greater of 1 inch or the reinforcing steel bar diameter for beams, walls and slabs, and the greater of 1 1/2 inches or 1.5 times the reinforcing steel bar diameter for columns.
   5. Beam and slab reinforcing steel bars shall be threaded through column vertical reinforcing steel bars without displacing the column reinforcing steel bars and still maintain clear distances for beam and slab reinforcing steel bars.

3.02 CONCRETE COVER

A. Unless specified otherwise on the Drawings or in the General Structural Notes, reinforcing steel bar cover shall conform to the following:
   1. Reinforcing steel bar cover shall be 3 inches for concrete cast against earth.
   2. Reinforcing steel bar cover shall be 2 inches for reinforcing steel bars for formed concrete surfaces exposed to earth and weather.
   3. Reinforcing steel bar cover shall be 2 inches for any formed surfaces exposed to or above any liquid.
   4. Reinforcing steel bar cover shall be 1 ½ inches for reinforcing not in the above categories unless noted otherwise on the design drawings.

3.03 SPLICING

A. Reinforcing steel splicing shall conform to the following:
   1. Use Class B splice lengths in accordance with ACI 318 for all reinforcing steel bars unless shown otherwise on the drawings.
   2. For welded wire fabric the splice lap length measured between the outermost cross wires of each fabric sheet shall not be less than one spacing of cross wires plus 2 inches, nor less than 1.5 times the development length nor less than 6 inches.
   3. Splices of reinforcement steel bars not specifically indicated or specified shall be subject to the approval of the Owner's Representative. Mechanical proprietary splice connections may be used when approved by the Owner's Representative or as indicated on the drawings.
   4. Welding of reinforcing steel bars is not allowed unless approved by the Owner's Representative.

3.04 CLEANING

A. Reinforcing steel bars at time of concrete placement shall be free of mud, oil, loose rust, or other materials that may affect or reduce bond. Reinforcing steel bars with rust, mill scale or a combination of both may be accepted without cleaning or brushing provided dimensions and weights including heights of deformation on a cleaned sample are not less than required by applicable ASTM standards.

3.05 PLACEMENT

A. Reinforcing steel bar placement shall conform to the following:
   1. Uncoated reinforcing steel bars shall be supported and fastened together to prevent displacement by construction loads or concrete placement. For concrete placed on ground, furnish concrete block supports or metal bar supports with non-metallic bottom plates. For concrete placed against forms furnish plastic or plastic coated metal chairs, runners, bolsters, spacers and hangers for the reinforcing steel bar support. Only tips in contact with the forms require a plastic coating.
   2. Fasten coated reinforcing steel bars together to prevent displacement. Use plastic or nylon ties to hold the coated reinforcing steel bars rigidly in place. Support coated reinforcing steel bars with plastic or plastic coated chairs, runners, bolsters, spacers and supports as required.
   3. Support reinforcing steel bars over cardboard void forms by means of concrete supports which will not puncture or damage the void forms nor impair the strength of the concrete member.
   4. Where parallel horizontal reinforcement in beams is indicated to be placed in two or more layers, reinforcing steel bars in the upper layers shall be placed directly over the reinforcing steel bars in the bottom layer with the clear distance between each layer to be 2 inches unless otherwise noted on the Drawings. Place spacer reinforcing steel bars at a maximum of 3'-0" on center to maintain the minimum clear spacing between layers.
   5. Extend reinforcement to within 2 inches of formed edges and 3 inches of the concrete perimeter when concrete is placed against earth.
   6. Reinforcing steel bars shall not be bent after embedding in hardened concrete unless approved by the Owner's Representative.

7. Tack welding or bending reinforcing steel bars by means of heat is prohibited.
8. Where required by the contract documents, reinforcing steel bars shall be embedded into the hardened concrete utilizing an adhesive anchoring system specifically manufactured for that application. Installation shall be per the manufacturer's written instructions.
9. Bars with kinks or with bends not shown shall not be used.
10. Heating or welding bars shall be performed in accordance with AWS D1.4 and shall only be permitted where specified or approved by the Owner's Representative. Bars shall not be welded at the bend.

3.06 REPAIR OF EPOXY COATING

A. Epoxy coating damage need not be repaired in cases where the damaged area is 0.1 square inch or smaller. Repair all damaged areas larger than 0.1 square inch in conformance with ASTM A775.

3.07 FIELD QUALITY CONTROL

A. Field quality control shall include the following:
   1. Notify the Owner's Representative whenever the specified clearances between the reinforcing steel bars cannot be met. The concrete shall not be placed until the Contractor submits a solution to the congestion problem and it has been approved by the Owner's Representative.
   2. The reinforcing steel bars may be moved as necessary to avoid other reinforcing steel bars, conduits or other embedded items provided the tolerance does not exceed that specified in this section. The Engineer's approval of the modified reinforcing steel arrangement is required where the specified tolerance is exceeded. No cutting of the reinforcing steel bars shall be done without written approval of the Owner's Representative.
   3. Coated reinforcing steel bars will be inspected on the jobsite for handling defects, coating abrasion, coating thickness and continuity of coating. The Owner's Representative may defer final inspection of the coated reinforcing steel bars until bar erection and handling is complete. Repair coated areas as directed by the Owner's Representative and completed prior to concrete placement.
   4. An independent laboratory shall be employed to review and approve Contractor welding procedures and qualify welders in accordance with AWS D1.4. The laboratory shall visually inspect each weld for visible defects and conduct non-destructive field testing (radiographic or magnetic particle) on not less than one sample for each 10 welds. If a defective weld is found, the previous 5 welds by the same welder shall also be tested.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast-in-place concrete, which consists of providing material, mixing, transporting equipment, and labor for the proportioning, mixing, transporting, placing, consolidating, finishing, curing, and protection of concrete in the structure.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related specification sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 60 00 Grouting
   2. Section 03 70 00 Mass Concrete
   3. Section 05 50 00 Metal Fabrications
   4. Section 07 91 26 Joint Fillers
   5. Section 07 92 00 Joint Sealants
   6. Section 09 90 00 Painting and Coating

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	Guide to Evaluation of Strength Test Results in Concrete
ACI 301	Specifications for Structural Concrete
ACI 305.1	Specification for Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.1	Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures
ACI 503.7	Specification for Crack Repair by Epoxy Injection
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C33	Concrete Aggregates
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C42	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C94	Ready-Mixed Concrete

Reference	Title
ASTM C117	Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Slump of Hydraulic Cement Concrete
ASTM C150	Portland Cement
ASTM C157	Length Change of Hardened Hyraulic-Cement Mortar and Concrete
ASTM C172	Sampling Freshly Mixed Concrete
ASTM C192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Air-Entraining Admixtures for Concrete
ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Chemical Admixtures for Concrete
ASTM C511	Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
ASTM C595	Blended Hydraulic Cements
ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Slag Cement for use in Concrete and Mortars
ASTM C1059	Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1077	Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1240	Silica Fume Used in Cementitious Mixtures
ASTM C1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1315	Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
ASTM C1567	Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Sampling Aggregates
ASTM D2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection
CRD-C572	U.S. Corps of Engineer's Specifications for Polyvinylchloride Waterstop
IBC	International Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

3. Check-marks (✓) denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance with the specification. Include a detailed, written justification for each deviation. Failure to include a copy of this marked-up specification section, along with justification(s) for requested deviations, with the submittal, is cause for rejection of the entire submittal with no further consideration.
4. Each proposed mix design showing:
    a. Expected strength at 7 and 28-days
    b. Slump, before and after introduction of high-range water-reducing admixture
    c. Water/cement ratio
    d. Weights and test results, certifications, and mill reports of the ingredients
    e. Chemical analysis report and report of other specified test analyses for supplementary cementitious material
    f. Aggregate gradation and documentation of test results classifying aggregate as non-potentially reactive
    g. Test results of mix design prepared by an independent testing laboratory
    h. Shrinkage test results for liquid containing structures
    i. Other physical properties necessary to review each mix design for conformance with these specifications
5. Mix designs proposed shall be sealed by a Professional Engineer registered in the state where the project is located. Mix designer shall be certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of Work.
6. Product literature and technical data for aggregates, cement, and pozzolan.
7. Product literature, technical data, and dosage of proposed admixtures including, but not limited to, air entraining, water reducing, retarding, shrinkage reducing, crystalline waterproofing, etc.
8. Anticipated average delivery time from batch plant to site. If this time exceeds the limit specified in Part 3, include proposed method to extend set time without deleterious effects on final product. Owner's Representative reserves the right to accept or reject such proposed methods.
9. Lift Drawings: Submit shop drawings for concrete placements on the project before on-site construction begins. The drawings shall be organized by structure and submitted as a complete set for the Engineer's review. The drawings shall be drawn to scale and show dimensions, forming details, and placement volumes. Show location of construction joints, details of surface preparation, scheduled finish, embedments (including conduits, inserts, and anchor bolts), penetrations (including pipe sleeves), openings, keyways, blockouts, bulkheads, etc. The drawings shall clearly show the placement sequence and will be accompanied by a schedule that shows the schedule dates for forming, placement, and stripping for each section of concrete placed within each structure.
10. Curing program description in sufficient detail to demonstrate that the Contractor will provide acceptable strength, finish, and crack control within the completed structure. Detailed plan for curing and protection of concrete in cold and hot weather.
11. Product literature and technical data for waterstops, curing and sealing compounds, bonding compounds, surface hardeners, epoxy and chemical grout for crack injection, retardant, bearing pads, and trench drains.

12. Sample panels at least 12-inches by 12-inches by three inches thick to demonstrate formed wall surface finishes as specified in Part 3.
13. Samples of concrete floor and slab for each finish specified in Part 3 approximately four feet square and a minimum of four inches thick, with one construction joint and one expansion joint, if used.
14. Concrete delivery truck tickets showing the information listed in ASTM C94, section 14.
15. Neoprene bearing pad sample, 4 inches x 4 inches; material data sheets verifying conformance with specification; shop drawing of each bearing pad showing splice locations, if any, and description of manufacturing and splice procedure.
16. Product data for prefabricated trench drains: material properties, cover, dimensions, and manufacturer's installation instructions.
17. Product data for floor type pressure relief valves.

1.05 QUALITY ASSURANCE

A. Quality Control By Owner:
   1. Special Inspection of concrete work shall be performed by the Special Inspector under contract with the Owner and in conformance with the IBC Chapter 17. Special Inspection of concrete is in addition to, not replacing, other inspections and quality control requirements specified herein. Where sampling and testing specified herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.
   2. All structural concrete work shall receive Special Inspection in accordance with IBC Chapter 17. Structural concrete includes elements which resist code-defined loads and whose failure would impact life safety. Non-structural site work concrete does not require Special Inspection. Anchor bolts and anchors installed in hardened concrete require Special Inspection.
   3. Refer to Section 01 45 23 Testing and Inspection Services for Owner provided testing.

B. Quality Control By Contractor:
   1. Where required to demonstrate conformance with the specified requirements for cast-in-place concrete, the Contractor shall provide the services of an independent testing laboratory which complies with the requirements of ASTM E329 and ASTM C1077. The testing laboratory shall sample and test concrete materials as specified in this section. Costs of testing laboratory services shall be borne by the Contractor.
   2. Concrete testing laboratory personnel shall be certified in accordance with the ACI Concrete Laboratory Testing Technician – Level 1 Certification Program or the ACI Concrete Strength Testing Technician Certification Program, or an equivalent program.
   3. Refer to Section 01 45 00 Contractor Quality Control.

C. Basis For Quality:
   1. Cast-in-place concrete shall conform to the requirements of ACI 301, except as modified herein.

D. Concrete Conference
    1. Contractor shall schedule and conduct a meeting to review the specification requirements and the proposed concrete design mixes, including procedures for producing proper concrete construction. Hold the meeting no later than 28 days after the Notice to Proceed.
    2. All parties involved in the concrete work shall be included to attend the conference, including the following: Contractor's representative, testing laboratory, concrete subcontractor, concrete supplier, reinforcing steel subcontractor, Owner's Representative, and Engineer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Cement:
    1. Store cement bags immediately upon receipt in a weatherproof structure as airtight as practicable. Elevate floor above ground to prevent absorption of moisture. Stack bags close together to reduce circulation of air but do not stack against outside walls. Stack to permit easy access for inspection and identification of each shipment.
    2. Transfer bulk cement to elevated airtight and weatherproof bins. At the time of use, cement shall be free flowing and free of lumps. Do not use cement which has been in storage longer than 6 months.

B. Aggregates:
    1. Store aggregates on areas covered with tightly laid wood planks, sheet metal, or other hard and clean surfaces in a manner that will preclude the inclusion of foreign material. Store aggregates of different sizes in separate piles. Build stock piles of coarse aggregate in horizontal layers exceeding 4 feet in depth to minimize segregation. Remix segregated aggregates to conform to the grading requirements.

C. Admixtures:
    1. Store admixtures to prevent damage. Do not use air-entraining admixture which has been in storage for longer than 6 months or has been frozen.

D. Pozzolan:
    1. Deliver and store pozzolan in the same manner as cement.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:
    1. Portland cement shall be ASTM C150, Type II or Type V, low alkali, containing less than 0.60 percent alkalis. In addition to standard requirements, cement shall satisfy optional chemical and physical requirements of ASTM C150, Tables 2 and 4, respectively.
    2. If low alkali portland cement is not available, test results shall be submitted showing aggregates meet the alkali-silica reactivity criteria in 2.01.D.1.b below.
    3. Blended Hydraulic Portland- cement shall be ASTM C595, Type IL (MS).
    4. Portland blast-furnace slag cement shall be ASTM C595, Type IS (<70) (MS), interground, low alkali.

5. Hydraulic cements meeting the performance specifications of ASTM C1157 are not permitted.
6. Use cementitious materials that are of the same brand and type and from the same plant of manufacture as the cementitious materials used in the concrete represented by the submitted field test records or used in the trial mixtures. See Change of Materials paragraph below.

B. Ground granulated blast-furnace slag (GGBFS), if used in conjunction with portland cement, shall be per ASTM C989, Grade 100 or Grade 120, limited to 50 percent of the weight of cementitious materials. If GGBFS is combined with pozzolans and/or silica fume, the total weight of GGBFS, pozzolans, and silica fume shall not exceed 50 percent of the weight of cementitious materials.

C. Silica fume, if used in conjunction with portland cement, shall be per ASTM C1240, limited to 10 percent of the weight of cementitious materials. Silica fume shall be used with a high-range water-reducing admixture.

D. Aggregates:
   1. General:
      a. Except as modified herein, fine and coarse aggregates shall conform to ASTM C33. Fine and coarse aggregates are regarded as separate ingredients. Aggregates shall be non-reactive and washed before use.
      b. Check aggregates for alkali-silica reactivity to meet the following criteria. Aggregates or combinations of cementitious materials and aggregates shall have less than 0.10% expansion at 16 days when tested in accordance with ASTM C1260 or ASTM C1567. Alternatively, aggregate tested independently in accordance with ASTM C1293 shall have less than 0.04% expansion at one-year, or combinations of aggregate and cementitious materials tested in accordance with ASTM C1293 shall have less than 0.04% expansion at two years. Test results shall be no older than two years.
      c. Tests for size and grading of fine and coarse aggregates shall be in accordance with ASTM C136. Combined aggregates shall be well and uniformly graded from coarse to fine sizes to produce a concrete that has optimum workability and consolidation characteristics. Establish the final combined aggregate gradation during mix design.
      d. Aggregates used in the project production concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by the submitted historical data or trial mixtures. See Change of Materials paragraph below.
   2. Fine Aggregate:
      a. Fine aggregate shall be hard, dense, durable particles of either sand or crushed stone regularly graded from coarse to fine. Gradation shall conform to ASTM C33. For classes of concrete which will be used in liquid retaining structures, fine aggregate shall not exceed 40 percent by weight of combined aggregate total, except for concrete with coarse aggregate of less than maximum size 1/2 inch.

b. Variations from the specified gradations in individual tests will be acceptable if the average of three consecutive tests is within the specified limits and the variation is within the permissible variation listed below:

U.S. standard sieve size	Permissible variation in individual tests, percent
30 and coarser	2
50 and finer	0.5

c. Other tests shall be in accordance with the following specifications:

Test	Test method	Requirements
Amount of material	ASTM C117	3 percent passing No. 200 sieve maximum by weight
Sand equivalent	ASTM D2419	Minimum 70 percent

3. Coarse Aggregate:
   a. Coarse aggregate shall be hard, dense and durable gravel or crushed rock free from injurious amounts of soft and friable particles, alkali, and organic matter. Other deleterious substances shall not exceed the limits listed in ASTM C33, Table 4 for Class Designation 4S. Gradation of each coarse aggregate size specified shall conform to ASTM C33, Table 3.
   b. Variations from the specified gradations will be acceptable in individual tests if the average of three consecutive tests is within the specified limits.

E. Pozzolan:
   1. Pozzolan shall be Class F fly ash conforming to ASTM C618. Class C fly ash is not allowed. Pozzolan supplied during the life of the project shall have been formed at the same single source. See Change of Materials paragraph below.
   2. The pozzolan color shall not substantially alter the resulting concrete from the normal gray color and appearance.
   3. Use pozzolan materials that are of the same brand and type and from the same plant of manufacture as the materials used in the concrete represented by the submitted field test records or used in the trial mixtures.
   4. The loss on ingnitition shall be a maximum of four percent.
   5. The maximum percent of sulfur trioxide (SO3) shall be 4.0

F. Admixtures:
   1. General:
      a. Admixtures shall be compatible with the concrete and with each other. Calcium chloride or admixtures containing calcium chloride are not acceptable. Use admixtures in accordance with the manufacturer's recommendations and add separately to the concrete mix. Water reducing retarders and admixtures shall reduce the water required by at least 11 percent for a given concrete consistency and shall comply with the water/cement ratio standards of ACI 211.1. Retarder dosage shall result in set time consistent with requirements specified in Part 3.
   2. Water Reducing Admixtures:
      a. Conform to ASTM C494, Type A. Acceptable products include: BASF Corporation “MasterPozzolith Series”; SIKA Chemical Corp. “Plastocrete 161”; Euclid Chemical Co. “Eucon WR 91”; or approved equal.

3. Water Reducing and Retarding Admixtures:
    a. Conform to ASTM C494, Type D. Acceptable products include: BASF Corporation "MasterSet R Series"; Sika Chemical Corp. "Plastiment"; Euclid Chemical Co. "Eucon Retarder 75"; or approved equal.
4. High Range Water Reducing (Superplasticizing) Admixtures:
    a. Conform to ASTM C494, Type F. Acceptable products include: BASF Corporation "MasterGlenium" Series; Sika Chemical Corp. "Viscocrete 2100" or "Viscocrete 2110" (Hot Weather) or "Viscocrete 6100" (Cold Weather); Euclid Chemical Co. "Eucon 37"; GCP Applied Technologies "ADVA 195"; or approved equal.
5. High Range Water Reducing And Retarding Admixtures:
    a. Conform to ASTM C494, Type G. Acceptable products include: GCP Applied Technologies "Daracem 100"; Sika Chemical Corp. "Sikaplast 200" ; Euclid Chemical Co. "Eucon 537"; or approved equal.
6. Air Entraining Agent:
    a. Conform to ASTM C260 and produce air entrained concrete as specified in the Mix Proportioning table below. Acceptable products include: BASF Corporation "MasterAir Series"; Sika Chemical Corp. "Sika AEA-14" or "Sika AIR" ; Euclid Chemical Co. "Eucon AEA-92"; or approved equal.
7. Shrinkage Reducing Admixture:
    a. Select admixture for compatibility with air entrainment admixture and other ingredients in the concrete mix. Acceptable products include: BASF Corporation "MasterLife SRA Series"; GCP Applied Technologies "Eclipse 4500"; or approved equal.
8. Crystalline Waterproofing Admixture:
    a. Select admixture for compatibility with other ingredients in the concrete mix. Acceptable products include: Penetron International "PENETRON ADMIX SB", Xypex "Admix C-Series", Kryton "Krystol Internal Membrane (KIM)", BASF Corporation "MasterLife 300D", or approved equal.
9. Corrosion Inhibiting Admixture:
    a. Select admixture for compatibility with other ingredients in the concrete mix. Acceptable products include: BASF "MasterLife CI 222", GCP Applied Technologies "DCI S", or approved equal.

G. Water:
1. For washing aggregate, mixing, and for curing shall be free from oil and deleterious amounts of acids, alkalis, and organic materials; comply with the requirements of ASTM C1602. Additionally, water used for curing shall not contain an amount of impurities sufficient to discolor the concrete.

H. Change of Materials:
1. After each concrete mix design is approved, no changes of any sort or source will be allowed without prior written approval from the Engineer. When brand, type, size, or source of cementitious materials, aggregates, water, ice, or admixtures are proposed to be changed, new field data, data from new trial mixtures, or evidence that indicates that the change will not affect adversely the relevant properties of the concrete shall be submitted for approval by the Engineer before use in concrete.

2.02 CONCRETE CHARACTERISTICS

A. Mix Proportioning:

1. Concrete shall be normal weight concrete composed of cement, pozzolan, admixtures, aggregates, and water; proportioned and mixed to produce a workable, strong, dense, and impermeable concrete. It is acceptable to substitute interground Portland-pozzolan cement conforming to ASTM C595, containing the specified amount of pozzolan in lieu of Portland cement and pozzolan. Water-cementitious material (w/cm) ratio is based on the combined contents of cement and pozzolan.
2. Add crystalline waterproofing admixture to Class C-1 concrete used for liquid containing structures and below-grade walls and slabs which are common with rooms, tunnels, and galleries to be occupied by equipment, piping, conduit, or personnel. Dosage rates in accordance with manufacturer's recommendations.
3. Add corrosion inhibiting admixture to Class A, C-1, and C-2 mixes.
4. Provide concrete mix designs in accordance with the following guidelines:

Concrete class	Minimum[a] 28-day compressive strength, psi	ASTM coarse aggregate size	Maximum water-cementitious materials (w/cm) ratio	Minimum cementitious materials content (pounds/CY)	Pozzolan, percent by weight of cementitious materials	Air content (percent)	Slump range[f] (inches)
A	4000[b]	467	0.42	515	20-35	4-6	3-5
B	3000	57 or 67	0.45	560	15-25[d]	4-6	3-5
C-1	4500	57 or 67	0.40	560	15-25	4-6	3-5
C-2	5000	57 or 67	0.40	560	15-25[d]	4-6	3-5
C-3	5000[g]	57 or 67	0.40	560	15-25[d]	4-6	3-5
D-1	4000	8	0.42	600	15-25[d]	4-6	3-5
D-2	5000	8	0.40	600	15-25	4-6	3-5
E[c]	2000	57	--	-	15-25[d]	Not Required	4-8
F	500[e]	-	--		15-25[d]	Not Required	4-8

[a] *Determine compressive strength at the end of 28 days based on test cylinders made and tested in accordance with ASTM C39.*

[b] *Compressive strength of Class A concrete may be determined at 56 days.*

[c] *Concrete encasement for electrical conduit shall contain 3 pounds of red oxide per sack of cement.*

[d] *Pozzolan use is optional for this class of concrete.*

[e] *Minimum 28-day compressive strength shall be 500 psi and maximum 28-day compressive strength shall be 1,000 psi.*

[f] *Slump before addition of high range water reducing admixture (superplasticizer). Maximum slump after addition of high range water reducing admixture shall be 8".*

[g] *.4500psi may be used for starter courses at class C-1 walls.*

B. Use:

1. Provide concrete by class for the uses listed below.

Concrete class	Type of use
A	Concrete greater than 36 inches thick See Section 03 70 00 for additional requirements
B	Non-structural concrete (sidewalks, curbs, pavers, etc.)
C-1	Typical cast-in-place structural concrete
C-2	Liquid-containing concrete
D-1	Topping concrete, flume interstitial "grout", and 2" concrete topping at clarifiers
D-2	Wall starter course
E[a]	Pipe bedding and encasement, electrical conduit encasement (duct banks) and concrete fill
F	Encasement of reinforcement extension for future construction

[a] *Contractor's option to use the same concrete mix for pipe encasement as the concrete slab above.*

C. Control Tests:

1. General:
   a. Select and adjust proportions of ingredients in accordance with ACI 211.1. Verification of mix characteristics for submittal may be achieved using either the Trial Mix Design method or Field Experience Data method. Do not place concrete prior to submittal and acceptance of proposed mix.
2. Trial Mix Design:
   a. Mixes verified by this method shall have the samples produced for testing, manufactured at the batch plant which will supply concrete to the project, using materials proposed for the Work and material combinations listed above. Testing, data, and reporting shall conform to ACI 318 and the following:
      1) Required compressive strength used as the basis for selecting concrete proportions (f'cr) shall be the specified concrete strength (f'c) + 1000 psi for specified concrete strengths less than 3,000 psi and f'c + 1200 psi for specified concrete strengths between 3000 psi and 5000 psi.
      2) Make at least three different trial mixtures for each class of concrete qualified by the Trial Mix Design. Each trial mixture shall have a different w/cm ratio or different cementitious materials content that will produce a range of compressive strengths encompassing f'cr.
      3) Design trial mixtures to produce a slump within ¾ inch of the maximum specified and an air content within 0.5 percent of the maximum specified.
      4) For each w/cm ratio or cementitious materials content, cast and cure at least twelve standard test cylinders in accordance with ASTM C192. Four cylinders from each batch tested at age 7-days, 14-days, and 28-days or as required to comply with ACI 318.
      5) From results of the cylinder tests, plot a curve showing the relationship between w/cm ratio and compressive strength.

6) From the curve of w/cm ratio versus compressive strength, select the w/cm ratio that will produce f'cr. This is the maximum w/cm ratio to be used unless a lower w/cm ratio is specified above.

3. Field Experience Data:
   a. When sufficient test data for a particular mix design is available which is identical or substantially similar to that proposed for use, Contractor may substitute use of this data in lieu of a trial mix design. Field data, reports, and analysis shall conform to ACI 318, except as modified herein.
      1) Historical mix design proportions for which data are submitted may vary from the specified mix within the following limits:
      a) f'c as specified or up to 500 psi above
      b) w/cm ratio as specified or lower
      c) pozzolan content within 5 percent of that specified
      d) maximum coarse aggregate size may not vary smaller, but gradation of coarse aggregate may vary
      e) slump after introduction of admixtures +0/-1 inch.
   b. Use of historical Field Experience Data does not allow modification of the project mix specifications herein without review and acceptance by the Engineer.
4. Shrinkage:
   a. Liquid containing structures using Class C-1 concrete mix are intended to be watertight. Provide test results for Class C-1 concrete mix meeting the following requirement: drying shrinkage limit of 0.038 percent in the laboratory at 35-days (7-days moist cure and 28-days drying) as tested in accordance with ASTM C157 and the following modifications:
      1) Wet cure specimens for a period of 7-days (including the period of time the specimens are in the mold). Wet cure may be achieved either through storage in a moist cabinet or room in accordance with ASTM C 511, or through storage in lime saturated water.
      2) Slump of concrete for testing shall match job requirements and need not be limited to restrictions as stated in ASTM C 157 section 8.4.
      3) Report results in accordance with ASTM C 157 at 0, 7, 14 & 28-days of drying.
   b. Concrete shall not be placed in the field prior to acceptance of the concrete mix. To meet the drying shrinkage limit, it is recommended that a shrinkage reducing admixture be considered for use in concrete for liquid containing structures.

2.03 WATERSTOPS

A. Polyvinyl Chloride (PVC):
   1. Manufacture PVC waterstops from virgin polyvinyl chloride conforming to the Corps of Engineers Specification No. CRD-C572.
   2. Use 6-inch by 3/8-inch ribbed flat ribbed with center bulb waterstop in construction joints. Acceptable products include: Greenstreak Group, Inc. "Model 705"; Vinylex Waterstops and Accessories "Model RB6-38; or approved equal.
   3. Use 9 inch by 3/8-inch ribbed with center bulb waterstop in expansion joints. Acceptable products include: Greenstreak Group, Inc. "Model 696"; Vinylex Waterstops and Accessories Model "RLB9-38"; or approved equal.

4. Use molded crosses, tees, and other shapes for changes of direction, intersections, and transitions as recommended by manufacturer.

B. hermoplastic:
   1. Acceptable products include: Greenstreak Group, Inc. “Westec Envirostop TPE-R”; Vinylex Waterstops and Accessories “Petro Stop”; or approved equal of similar profiles to above specified PVC waterstops.

C. Retro-Fit:
   1. Use “Tee” or “L” shape as indicated with epoxy adhesive, stainless steel batten strips, and stainless steel adhesive anchors. Acceptable products include: Greenstreak Group, Inc Model “667” or approved equal.

D. Expanding (Hydrophilic) Waterstops:
   1. Bentonite-free, made from unvulcanized rubber. Acceptable products include: Adeka Corporation “Ultra Seal MC-2010MN with P-201 adhesive/sealant”; Greenstreak Group, Inc. “Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive/sealant”; or approved equal. These are allowable for use only where indicated on the drawings or accepted in writing by Engineer. Provide adhesive/sealant approved by manufacturer plus concrete nails and fender washers to secure waterstop material in-place during concrete placement. The waterstop MUST be placed between two mats or curtains of steel reinforcementwith minimum 3-inches concrete cover.
   2. For limited cover applications or where only one mat or curtain of reinforcement is present, use Adeka Corporation “Ultra Seal KBA-1510FP”or approved equal.

E. Non-expanding Waterstops:
   1. Acceptable products include: Henry Company “SF302 Synko-Flex Waterstop with primer” or approved equal.

F. Chemical Grout Injected Tube:
   1. Acceptable products include: De Neef Construction Chemicals “Injecto System” or approved equal.

2.04 SEALANTS AND JOINT FILLERS

A. Sealants and preformed joint fillers are specified in Sections 07 92 00 and 07 91 26.

2.05 BONDING COMPOUNDS

A. Epoxy resin bonding compounds for use in wet areas shall conform to ASTM C881 Types IV or V, Class A, B, or C depending on temperature at use. Acceptable products include: BASF Corporation “MasterEmaco ADH 327RS”; Sika Chemical Corporation “Sikadur 32”; or approved equal.

B. Non-epoxy bonding compounds for use in dry areas for non-structural bonding or as noted on the drawings shall conform to ASTM C1059 Type II. Acceptable products include: Penetron Specialty Products “Acrylic Bondcrete”; ChemMasters “Cretelox”; or approved equal.

C. Apply bonding compounds in accordance with the manufacturer’s instructions.

2.06 EPOXY FOR CRACK INJECTION

A. Use a two-component, moisture insensitive, high modulus, injection grade, 100 percent solids, epoxy-resin blend. Consistency as required to achieve complete penetration into cracks. Material shall conform to ASTM C881 Type 1 Grade 1. Acceptable products include: Sika Corporation “Sikadur 52”; Adhesives Technology Corporation “Crackbond SLV302”; or approved equal.

B. Use epoxy injection for structural crack repairs except as noted below for non-structural cracks in liquid-containing concrete structures. The Engineer shall determine whether a crack is classified as structural or non-structural.

2.07 CHEMICAL GROUT FOR CRACK INJECTION

A. Use hydrophobic polyurethane grout at the Engineer's discretion as an alternative for sealing non-structural cracks in concrete structures intended to be watertight. Acceptable products for sealing hairline cracks include: GCP Applied Technologies "DE NEEF Flex SLV PURe” (must be used with DE NEEF Flex Cat PURe); or Sika Corporation “SikaFix HH LV” as appropriate for crack width; or approved equal. Coordinate with product supplier to verify and select appropriate product for crack widths to be injected.

2.08 SURFACE RETARDANT

A. Retardant for exposing aggregate for unformed surfaces in construction joints shall be Sika Corporation“Rugasol-S”; GCP Applied Technologies “Top-Cast”; or approved equal.

B. Apply retardant in accordance with manufacturer’s instructions sufficient to assure a minimum penetration of 1/4 inch.

2.09 SURFACE HARDENER

A. Moderate Duty Hardener:
   1. Use a premixed, non-colored, and non-metallic hardener. Acceptable products include: BASF Corporation “MasterTop 100”; or approved equal.
   2. Apply hardener in accordance with manufacturer’s instructions, in an amount of at least 0.75 pounds per square foot for commercial, light duty traffic and 1.25 pounds per square foot for heavy duty traffic and process spaces. Product and/or application procedure shall be coordinated with air content of concrete being placed.

B. Heavy Duty Hardener:
   1. Use an emery aggregate dry shake applied during slab finishing. Acceptable products include: L&M Construction Chemicals “Emeryplate FF”; or approved equal.
   2. Apply in accordance with manufacturer’s recommendations at a minimum rate of 1.5 pounds per square foot; adjust for the specific floor traffic and use anticipated. Product and/or application procedure shall be coordinated with air content of concrete being placed.

C. Hardener For Existing Concrete:
   1. Use an alkaline siliconate solution to harden, densify, and seal the surface. Acceptable products include: L&M Construction Chemicals “Seal Hard”; or approved equal.

2. Proposed product shall be approved by Owner after review of similar floors so-treated for at least 2 years.

2.10 CURING AND SEALING COMPOUNDS

A. Acceptable products include: BASF Corporation “MasterKure CC 250SB”; Dayton Superior “Cure & Seal 25% J22UV”; or approved equal, conforming to ASTM C1315.

B. Compound shall be clear and applied in accordance with the manufacturer’s instructions.

C. Curing and sealing compound shall be certified compliant with final finish system if applicable, including compatibility with floor hardeners in areas where floor hardeners are specified to be used.

D. Acceptable products include: Atlas Tech Products “Atlas Quantum-Cure 61”; or approved equal certified to conform to NSF/ANSI Standard 61.

E. Compound shall be clear and applied in accordance with the manufacturer’s instructions.

F. Curing compounds shall be certified compliant with final finish system if applicable, including compatibility with floor hardeners in areas where floor hardeners are specified to be used.

2.11 FLOOR TYPE PRESSURE RELIEF VALVES

A. Where indicated on design drawings, floor type hydrostatic pressure relief valves shall be provided for installation in the bottom slab of reinforced concrete liquid containing tanks to limit groundwater uplift pressure.

B. Size of valve: 6 inch inside diameter; length to suit slab thickness, provide PVC extension as required. Valve shall start to open under a minimum hydrostatic head of 9 inches.

C. The valve assembly shall consist of three parts: cover, body and grate. All three parts shall be of cast iron conforming to ASTM A126. The cover or the grate shall not become separated from the body of the valve due to groundwater pressure around the tank.

D. Both cover and grate must be removable for valve inspection by turning left or right to free them from integrally cast locking lugs on the inside of the valve body.

E. Valve seats shall be of BUNA-N rubber, bonded to the cover, mating with a machined bronze seat in the body.

F. Valve shall have an integrally cast seepage ring around the outside of the body.

G. Acceptable products include: Clow Valve Company “F-1493-T; Neenah Foundry Company “No. R-5001-1 Type A; Troy Valve “No. A2550RSN”, or equal.

2.12 TRENCH DRAINS

A. Use either field formed and cast with grate and frame, or utilize a pre-engineered manufactured trench drain system that conforms to the design load requirements of AASHTO H-20 in traffic areas or 300 pounds per square foot elsewhere. Include the following minimum requirements:
   1. A round or V-bottom channel, sloped to a minimum of 1/16-inch per foot. See drawings for channel cross section or size. If not shown, use 12 inches wide and deep (nominal) and confirm with Owner's Representative.
   2. Aluminum grating frame with anchors at 45 degrees into the surrounding concrete. Coat aluminum to prevent direct concrete contact.
   3. Aluminum grate conforming to Federal Specification RR-F-621C.
   4. A locking device which directly connects the grate to the frame.

B. Candidate manufacturers include: MultiDrain Systems, Atlanta, Georgia; ABT, Inc., Troutman, North Carolina; or approved equal.

2.13 NEOPRENE BEARING, SEAL PADS, AND RODS

A. Use 100 percent chloroprene (neoprene), 50 Durometer A, conforming to AASHTO Standard Specifications for Highway Bridges. Pads and rods shall conform to geometry as shown on the drawings. Products shall be one-piece as manufactured, or factory spliced; using a process proven gas-tight in repeated similar applications. Do not use glues and adhesives to bond pieces together.
   1. Deliver to job site in protective containers or packaging and maintain the integrity of the pad/rod through construction.

PART 3 EXECUTION

3.01 GENERAL

A. Use only truck-mixed, ready-mixed concrete conforming to ASTM C94. Proportion materials by weighing.

B. Introduce pozzolan into the mixer with cement and other components of the concrete mix; do not introduce pozzolan into a wet mixer ahead of other materials or with mixing water.

C. Introduce water at the time of charging the mixer; additional water may be introduced within 45 minutes from charging the mixer, provided the specified w/c ration and slump is not exceeded and the maximum total water per the approved mix design is not exceeded.

D. Arrange with the testing laboratory for inspection as required to comply with these specifications.

E. Deliver concrete to the site and complete discharge within 90 minutes after introduction of water to the mixture. Extension of allowable time beyond this limit requires a Contractor proposed remedial action plan to be reviewed and accepted by the Owner's Representative.

3.02 BATCHING:

A. General:

1. Batch concrete only from equipment with a current National Ready Mix Concrete Association Certificate of Compliance. Provide and maintain such means and equipment as are required to accurately determine and control the relative amounts of the various materials, including water, cement, pozzolan, admixtures, sand and each size of coarse aggregate used in the concrete.
2. Proportion concrete batches on the basis of integral sacks of cement unless the cement is weighed. Introduce pozzolan into the mixture only with cement and other dry components of the concrete mix. Do not introduce pozzolan into wet mixer ahead of other materials or with mixing water. Determine amounts of sand and coarse aggregate required for each batch of concrete by weighing, and the required water by either weighing or metering.
3. Deposit aggregates in the batch bins directly over the discharge gates. Deposit coarse aggregate in the batch bins through rock ladders when the free drop of the aggregate exceeds 4 feet. Convey batch materials from the weighing and batching hoppers so that there will be no spillage of the batched materials or overlapping of batches.
4. Provide sufficient trucks to continuously deliver batched material. Each truck shall carry a delivery ticket showing the mix number, size of batch, and time water was added to the batch.

B. Weighing And Metering Equipment:

1. Equipment shall be sealed by the state agency having authority over weights and measures and shall be capable of adjustment for compensating for the varying weights and moisture changes which affect the concrete mix proportions and concrete consistencies.
2. Batching equipment shall be constructed and operated so that when the entire plant is running, the combined inaccuracies in feeding and measuring materials will not exceed 1 percent for water or cement and pozzolan, 2 percent for any size of aggregate, and 1 1/2 percent for the total aggregate in any batch.
3. Design equipment for convenient confirmation of the accuracy required for each batch. The equipment for measuring water shall not leak when the valves are closed.
4. Provide standard test weights and other auxiliary equipment required for checking the operating performance of each scale or meter and make tests at intervals of not more than 6 months in the presence of the state inspector. Provide copies of the complete results of check tests made, and make such adjustments, repairs, or replacements as necessary to secure satisfactory performance.
5. Where the batch plant involves the use of storage bins and weighing hoppers, each weighing unit shall include a visible springless dial or equally suitable device which will register the scale load at any stage of the weighing operation from zero to full capacity. Construct weighing hoppers to permit the convenient removal of overweight material in excess of the prescribed tolerances. Each dial and water-measuring device shall be in view of the operator and, if practicable, arrange the weighing equipment so that the operator may conveniently observe the operation of the bin gates and also the materials discharged into the mixer hopper.

6. Batching equipment in automatic plants shall be interlocked so that:
    a. A new weighing cycle cannot be started until the batchers are emptied and the dispatcher discharge gates and valves are closed.
    b. The batcher discharge gate cannot be opened until the correct weights of the materials are in the batching hoppers and the scales in balance.
    c. The discharge gates cannot be closed until materials are entirely discharged from the hopper and are back in balance.
    d. The water batcher discharge valve cannot be opened until the filling valve is closed. The admixture dispenser shall be interlocked to operate with the water batcher.
7. Dispensers for admixtures shall have sufficient capacity to measure at one time the full quantity of solution required for each batch. Add admixtures to premeasured water for the batch, or arrange their discharge into the batch to flow uniformly into the water stream for the batch from beginning to end of its flow into the mixer. Dosages of admixtures shall not vary from the required dosage by more than 5 percent.

3.03 MIXING:

A. Mix the concrete ingredients in batch mixers until the mixture is homogeneous and uniform in consistency. Mix each batch for at least 1 1/2 minutes for concrete not containing pozzolan and for at least 2 minutes for concrete containing pozzolan after all the ingredients, except the full amount of water, are in the mixer. The minimum mixing period specified is predicated on control of the speed of rotation of the mixer and the introduction of materials, including water, into the mixer.

B. Add water prior to, during, and following the mixer charging operations. Excessive mixing time requiring the addition of water (retempering) to preserve and secure the required concrete consistency is not acceptable.

C. Mixers shall not be loaded in excess of their rated capacity. Equip each mixer with a satisfactory mechanically operated timing, signaling (or locking), and metering device for indicating and assuring the completion of the required mixing period and for counting the batches.

3.04 CONVEYING AND PLACING CONCRETE

A. Convey concrete from the mixer to the forms in accordance with ACI 301. Remove concrete that has segregated in conveying from the site of the work.

B. Placing Concrete:
    1. General:
        a. Place concrete in accordance with ACI 301. Do not permit concrete to drop freely more than 4-ft (6-ft when superplasticizer is used).
    2. Placing Concrete By Pumping:
        a. Concrete placed by pumping is at Contractor's discretion and shall not be the cause to change or relax specified mix design characteristics. Concrete shall possess the specified characteristics at the point of placement.

b. Measure slump at the hose discharge, except as follows: Initial slump testing in each placement shall occur at both the pumping unit inlet hopper and hose discharge. Slump loss in pumping, measured between the inlet hopper and the hose discharge, shall not exceed 1 inch. After these criteria have been satisfied, slump may be measured at the inlet hopper with allowable slump increased by the earlier measured difference, not to exceed 1 inch.

c. Measure air content at the hose discharge, except as follows: Initial air content testing shall occur at both the pumping unit inlet hopper and the hose discharge. Loss of air content shall be measured between the inlet hopper and the hose discharge. Increase the air content of the delivered concrete at the inlet hopper to provide the specified air content at the hose discharge. After these criteria have been satisfied, air content may be measured at the inlet hopper.

d. Before starting each pumping operation, prime the pump and line with a cement slurry to lubricate the system. Waste cement slurry outside the forms. Equip hose tip with a safety chain for recovery in case of hose blowout during pumping. Hose or accessories shall not remain in the freshly placed concrete.

e. Use tremie placing techniques and equipment for pump placed concrete. Pump discharge system shall remain full of concrete from pump to discharge point at all times. Concrete pumping shall not occur until Owner's Representative has verified equipment including the tremie plug. Should the discharge line become open, with zones empty of concrete, cease pumping and re-primed with tremie plug installed before continuing.

3. Placing Concrete In Hot Weather:
   a. In temperatures above 80 degrees F, place concrete in accordance with ACI 305.1.
4. Placing Concrete In Cold Weather:
   a. In temperatures below 40 degrees F, place concrete in accordance with ACI 306.1.
5. Starter Course At Waterstops:
   a. When placing concrete in wall forms for liquid containing structures over 8 feet in height and without form windows, use a starter course of Class D-2 concrete placed to a uniform consolidated depth of approximately 6 inches. Subsequent lift of Class C-1 or C-2 concrete shall be placed onto this starter course within 10 minutes of the starter course placement, and the two lifts consolidated together with no cold joint.

3.05 CONSOLIDATING CONCRETE:

A. Consolidate concrete in accordance with ACI 301. If evidence of inadequate consolidation is observed, concrete placement will be suspended until Contractor provides a revised plan to achieve proper consolidation.

3.06 CURING AND SEALING

A. General:
   1. Cure concrete using water (including form curing and use of moister retaining covers), a clear membrane curing compound, or by a combination of both methods. Coordinate repairs or treatment of concrete surfaces so that interruption of curing will not be necessary.

2. Maintain concrete surface temperature between 50 degrees F and 80 degrees F for at least 5 days. Cure concrete in hot weather (above 80 degrees F) in accordance with ACI 305.1. Cure concrete in cold weather (below 45 degrees F) in accordance with ACI 306.1.

B. Water Curing:
   1. Keep concrete continuously wet for a minimum of 10-days after placement (14 days after placement for sections over 3-feet thick). Absorptive mats or fabric may be used to retain moisture during the curing period. Absorptive covers shall comply with AASHTO M182, Class 3, and moisture retaining covers shall comply with ASTM C171.
   2. Use water curing in hot weather for liquid containment structures. Cover forms and keep moist. Loosen forms as soon as possible without damage to the concrete, and make provisions for curing water to run down inside them. During form removal, take care to provide continuously wet cover to newly exposed surfaces.

C. Curing Compound:
   1. When curing compound is allowed, apply it as soon as the concrete has set sufficiently so as not to be marred by the application or apply it immediately following form removal for vertical and other formed surfaces. Preparation of surfaces, application procedures, and installation precautions shall follow manufacturer's instructions. For liquid containing structures, apply curing compound at twice the manufacturer's recommended dosage rate, applied in two coats perpendicular to each other.
   2. Do not use curing compound on concrete surfaces to be coated, waterproofed, moisture-proofed, tiled, roofed, or where other coverings are to be bonded. In these cases, use water curing unless the curing compound is first removed or is compatible with the final finish covering.

3.07 PROTECTION

A. Protect concrete from injurious action by sun, rain, wind, flowing water, frost, excessive vibration and mechanical means.

B. Loading green concrete is not permitted. Green concrete is defined as concrete with less than 100 percent of the specified strength.

C. Backfill shall not be placed against concrete walls until the concrete has reached the specified strength, connecting slabs and beams have been cast and have also reached the specified strength, and watertightness testing and repairs have been completed for liquid containing structures to the satisfaction of the Owner's Representative.

D. Arrangements for covering, insulating, heating, and protecting concrete in cold weather shall be in accordance with ACI 306.1.

3.08 CONSTRUCTION JOINTS

A. General:
   1. Place concrete in each unit of construction continuously. Before new concrete is placed on or against concrete which has set, retighten forms and clean foreign matter from the surface of the set concrete. Provide waterstops as specified.

B. Construction:

1. Form construction joints by producing a rough surface of exposed aggregates using a surface retardant; include joints between the slab and topping concrete. The limit of the treated surfaces shall be 1 inch away from the joint edges. Within 24 hours after placing, remove retarded surface mortar either by high pressure water jetting or stiff brushing or combination of both so as to expose coarse aggregate. A rough surface of exposed aggregate may also be produced by sandblasting followed by high pressure water jetting. Sandblasting, if used, shall remove 1/4 inch of laitance film and expose coarse aggregate to ensure adequate bond and watertightness at the construction joints.

C. Locations:

1. Provide construction joint locations as follows:
    a. Cast walls exceeding 50 feet in length in panels not to exceed 30 feet in length. Cast adjoining panels only after 5-days have elapsed. Joints are not allowed within the lesser of 10 feet or 25 percent of the wall length from a corner unless specifically detailed thus on the drawings.
    b. Locate joints in beams or girders at or near the quarter point between supports.
    c. Make joints in the members of a floor system at or near the quarterpoint of the span.
    d. Make joints in walls and columns at the underside of floors, slabs, beams or girders and at the tops of footings or floor slabs.
    e. Cast slab panels in checkerboard patterns not to exceed 40 feet in length and not to exceed 900 square feet in area, with maximum 1 ½ to 1 ratio of side lengths. Minimum lapsed time between placing adjacent panels shall be 3-days. The requirements for size of slab panel is waived if joints are located on the Drawings.
2. Vertical construction joints shall have edges grooved or beveled at faces exposed to view including interior faces of basins and tanks. Seal grooves subjected to wetting or weather with joint sealant.
3. Continue reinforcing steel and welded wire reinforcement through construction joints. Beams, girders, and floor slabs shall not be constructed over columns or walls until at least one day has elapsed to allow for initial shrinkage in the column or wall. No joint will be allowed between a slab and a beam or girder unless otherwise shown. Joints shall be perpendicular to the main reinforcement. Provide waterstops in construction joints as specified.

3.09 INSERTS AND EMBEDMENTS

A. Inserts:

1. Where pipes, castings, or conduits are to pass through structures, position in forms before placing concrete; or where shown on Drawings or approved by the Owner's Representative, provide openings in the concrete for subsequent insertion of such pipes, castings, or conduits. Provide waterstops and a slight flare in the form to facilitate grouting and permit the escape of entrained air during grouting.
2. Provide additional reinforcement around openings. Use non-shrink grout to infill around inserts.

3. Place horizontal conduits and pipes, in slabs and beams, between the top and bottom layers of reinforcement. Spacing and size limitations shall conform to ACI 318.
4. Conduits and pipes shall not run directly beneath a column or base plate.
5. Position conduit, pipe, and other ferrous items such that there will be a minimum of 2-inches clearance between said item and concrete reinforcement. Welding inserts to reinforcement is not permitted.
6. The outside diameter of conduit or pipe shall not exceed one-fourth the slab or beam thickness.

B. Embedments:
1. Gate frames, gate thimbles, special castings, channels, grating frames, or other miscellaneous metal parts to be embedded in concrete shall be secured in the forms prior to concrete placement.
2. Embed anchor bolts and inserts in concrete as shown. Provide inserts, anchors, or other bolts necessary for the attachment of piping, valves, metal parts, and equipment.
3. Provide nailing blocks, plugs, strips, and the like necessary for the attachment of trim, finish, and similar work. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent entry of concrete. Do not use continuous anchor slots or strips in concrete intended to be watertight.
4. Position operators or sleeves for gate or valve stems to clear reinforcing steel, conduit, and other embedments, and to align accurately with equipment.

3.10 WATERSTOPS

A. Waterstops shall conform to ACI 301. Tie waterstops in position prior to placement of concrete to prevent movement and deformation.

B. Provide waterstops in construction and expansion joints as follows:
1. Joints in parts of structures exposed to ground or water on one side and occupied by non-submerged equipment or by personnel on the other.
2. Wall and slab joints of tanks and channels subject to water pressure.
3. Waterstops shall be provided for the full height of the walls.
4. Provide at other locations shown on the Drawings.

C. Field splices shall be at straight sections using heat fused welded, butt splices only. Lapping of splices or joining by means other than heat fused welding is not allowed.

D. Install hydrophilic waterstops according to manufacturer's recommendations. Surfaces of concrete shall be prepared level/plumb and to the smoothness required by manufacturer. Grind surface as necessary. Provide bonding adhesive and concrete nails with fender washers to hold waterstop in position during concrete placement.

3.11 FLOOR TYPE PRESSURE RELIEF VALVES

A. Pressure relief valves or other miscellaneous metal parts to be embedded in concrete shall be secured in place prior to concrete placement. Position pressure relief valves to clear reinforcing steel and other embedments.

B. Install in accordance with manufacturer's recommended instructions.

C. Install valve in a vertical position.

D. Prevent damage to valve seats during installation and pouring of concrete slab.

E. Frequency of inspection shall be as recommended by the manufacturer.

3.12 MODIFICATION OF EXISTING CONCRETE

A. General:
   1. Verify structural dimensions related to or controlled by previously constructed or existing structures prior to concrete work.

B. Cutting or Coring Concrete:
   1. Saw cut concrete to a depth of 1 inch to form straight outlines of concrete areas to be removed. Where reinforcement is exposed due to saw cutting or core drilling and no new material is to be placed on the cut surface, provide a protective epoxy coating to the entire cut surface.
   2. Coat surfaces of oversized openings with an epoxy bonding compound prior to re-finishing with profiling mortar to the required opening size.
   3. Grind existing joint edges to create a chamfer matching those used on adjacent construction.
   4. Investigate concrete to be drilled, cored, or sawcut to determine location of reinforcing steel. Locate penetrations to clear existing reinforcing steel. Where not possible to avoid reinforcing steel, consult the Engineer as to acceptability of cutting reinforcing steel and provide new reinforcing systems as directed.
   5. Locating methods include chipping to expose reinforcing steel, ground penetrating radar, X-ray, or magnetic flux devices. Locates of existing reinforcing shall be by the Contractor.

C. Joining New Concrete To Existing:
   1. Existing concrete surfaces to be joined with new concrete shall be cleaned and roughened by abrasive blasting, bush hammering, or other method to achieve ¼-inch amplitude surface. Remove existing metalwork, embeds, or other interfering items. Coat existing surface with epoxy bonding compound prior to placement of new concrete.

D. Post-Installed Anchors and Dowels:
   1. Use non-destructive methods for locating reinforcement prior to drilling operations. For anchor and dowel locations that interfere with reinforcement, attempt to relocate to avoid drilling through the reinforcement if possible.
   2. For situations that do not allow relocation, cutting of reinforcement for installation is subject to the following:
      a. Prior to drilling through reinforcement, the Contractor shall consult the Owner's Representative or Engineer.
      b. Drill holes with a hammer drill and carbide bit (core drilled holes are not allowed), followed by brushing and air-cleaning with oil-free compressed air.

c. Holes drilled through reinforcement must be in compliance with adhesive anchor assumptions for roughened hole surface typical of a hammer drill and carbide bit. No smooth hole surfaces are allowed.
d. Do not cut slab rebar within 24 inches of a supporting wall, column, or an opening in the slab.
e. No cutting of rebar is allowed in the middle third of slab spans for anchors with diameters equal to or greater than 3/4 inch.
f. Maximum of two rebar may be cut in any 10 foot width of slab.
g. Maximum of two rebar may be cut within any 10 foot width of concrete wall.
h. Maximum of one rebar may be cut within any 8 foot width of CMU wall.

3. For anchors that cannot be moved and that conflict with the above requirements, consult Engineer for direction. It is not acceptable to cut reinforcement in beams, columns, precast members, or stairs.
4. Use a pre-manufactured, self-mixing, injectable, two-component, epoxy adhesive, as per Section 03 60 00. Follow manufacturer's recommendations and ICC Evaluation Report for installation.

E. Waterstops:
1. Where a waterstop between new and existing concrete is required, install a hydrophilic waterstop, or a retrofit waterstop where indicated on the design drawings for the specific location.

3.13 FORMED SURFACE FINISHES

A. Repair Of Surface Defects:
1. Repair surface defects, including tie holes, minor honeycombing, or otherwise defective concrete in accordance with ACI 301. Clean areas to be repaired. Cut and chip out honeycombed or otherwise defective areas to solid concrete, to a depth of at least 1-inch. If defective area includes exposed reinforcing steel, correct by removing concrete a minimum of 1-inch beyond the reinforcing. Make edges of the cut perpendicular to the surface of the concrete in a neat rectangular pattern.
2. Joints shall be grooved to a radius or bevel of ¾-inch depth.
3. Finish patches on exposed surfaces to match and blend with adjoining work. Cure patches as specified for the concrete. Protect finished surfaces from stains and abrasions.

B. Formed Surface Finishes:
1. Finish A - Grout Rubbed Finish
a. After repair of surface defects, apply a grout rubbed finish in accordance with ACI 301 except that all form fins and other protrusions shall be completely removed. Lightly sandblast surfaces prior to sacking. Sandblasting shall occur after the specified curing period.
b. Add a PVA bonding compound to the mix water used in sacking mortar; as recommended by the manufacturer.

c. Provide Finish A at uncoated surfaces of stair wells, at interior surfaces of equipment rooms, galleries, tunnels, operations areas, exposed channels and tanks from 1 foot below minimum water surfaces and up, at exposed exterior surfaces to 1 foot below grade, and at permanently exposed vertical and sloped surfaces such as pipe chases.

d. Do not provide Finish A at concrete surfaces receiving a coating.

2. Finish B - Smooth Surface Finish
    a. Initial surface preparation is the same as Finish A; repair surface defects and remove all form fins.
    b. Provide Finish B at surfaces to be coated, at interior surfaces of exposed channels and tanks from 1 foot below minimum water surfaces and down (Finish A applied above this level), and full height at surfaces of wet wells, tanks, and channels not exposed to view. See Section 09 90 00 for additional concrete surface preparation, including filling of bug holes, and coating requirements.
3. Finish C - Rough Form Finish
    a. Repair surface defects and imperfections greater than 3/8 inch in any dimension. Remove form fins and protrusions down to less than 3/8 inch projection.
    b. Provide Finish C or smoother at exterior surfaces from 1 foot below grade and down, at other vertical surfaces not exposed to view and not specified above to receive Finish A or B.
    c. Also apply Finish C to unoccupied interior areas not otherwise specified.
4. Finish D – Unfinished Surface
    a. Repair surface defects and otherwise leave the surfaces as they come from the forms, except plug tie holes and repair or remove defects greater than 1/2 inch in any dimension.

C. Sample Of Formed Surface Finish A:
1. Provide a sample concrete panel, minimum 4 feet by 4 feet; representative of formed surface Finish A. The panel shall be representative of the workmanship and finish required, including repair of defects, filling of tie holes, sandblasting, and rubbing.
2. The sample shall be approved by the Owner's Representative prior to the start of production work. The sample shall be on display at the job site, and finished surfaces shall match sample.

3.14 SLAB FINISHES

A. General:
1. The finishes specified herein include surface finishes, treatments and toppings for floors and slabs. Do not use dry cement on new concrete surfaces to absorb excess moisture. Round edges to a radius of 1/2 inch.
2. Slope floors to drain uniformly within a room or space. Unless otherwise specified, slope shall be a minimum of 1/8 inch per foot toward nearest drain. Restrict use of floor drains with only locally depressed slabs to locations specifically noted.
3. Immediately after final finish is applied, the surface shall be cured and protected as specified in Curing, Sealing, and Protection paragraphs above.
4. Where finish is not specified, floor slabs shall receive a Steel Trowel Finish.

B. Float Finish:
   1. Perform floating with a hand or power-driven float in accordance with ACI 301. Begin floating when the bleed water sheen has disappeared and the surface has stiffened sufficiently. Float as required to meet tolerance requirements of ACI 117 for a conventional surface.
   2. Floating shall close cracks and checks plus compact and smooth the surface. Refloat the slab to a uniform texture.
   3. Apply float finish to surfaces of channels, tank bottom slabs, exterior below grade horizontal surfaces, including tops of footings, and surfaces to receive insulation or roofing.

C. Steel Trowel Finish:
   1. Float the concrete surface as indicated above and then trowel in accordance with ACI 301.
   2. Provide Steel Trowel Finish on interior exposed floors and slabs that will receive resilient flooring, carpet or ceramic tile, unless specified otherwise.
   3. Surface Hardener (see Part 2) shall be troweled into the finished surface at the following locations shown on the drawings.

D. Broom Finish:
   1. Float the concrete surface as indicated above, then immediately give the concrete a coarse transverse scored texture by drawing a broom or burlap belt across the surface in accordance with ACI 301.
   2. Provide a Broom Finish for steps and ramps, exterior exposed horizontal surfaces, and where otherwise indicated.

E. Samples Of Concrete Slab Finishes:
   1. Provide a sample concrete slab, minimum 4 feet by 4 feet, representative of workmanship and each specified finish.
   2. Samples shall be approved by the Owner's Representative prior to the start of production work. The samples shall be on display at the job site, and finished surfaces shall match samples.

3.15 TOPPING CONCRETE

A. Subfloor Finish:
   1. Slabs to receive a topping concrete, topping grout, or tile; shall be float finished to required elevations. Immediately following the final finishing, either:
      a. treat slab with a retardant and abrasive blast to create expose aggregate with ¼ inch amplitude, or
      b. create the ¼ inch amplitude roughened surface by raking the freshly floated surface using a standard garden rake.
   2. Immediately after finishing, proceed with required curing and protection of the slab as stated above.

B. Topping Concrete or Grout:
   1. Remove dirt, laitance, and loose aggregate. Keep cleaned base slab saturated surface dry for a period of 24 hours prior to the application of topping. Remove excess water.
   2. Apply and scrub a neat cement grout into the surface of the base slab using a stiff broom. The cement grout shall not be allowed to dry and shall be spread within 15 minutes ahead of the topping placement.
   3. The topping shall then be placed, compacted, and floated. Test surface with a straight edge to detect and correct high and low spots to a tolerance of 1/8 inch in 10 feet.
   4. Incorporate float finish, surface hardener, steel trowel finish, etc. as specified.

3.16 RELATED SURFACES

A. Stair Treads:
   1. Construct stair treads with a nonskid nosing as specified in Section 05 50 00.
   2. Treads shall have a Float Finish followed by a Steel Trowel Finish with a slope of 1/8 inch toward the front.
   3. Ends of treads shall have a 1/16 to 1/8 inch cut between concrete and metal tread to allow for expansion.

B. Finishing of Unformed Surfaces:
   1. Adjacent Unformed Surfaces:
      a. Tops of walls, buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be Float Finished to a texture reasonably consistent with that of the adjacent formed surface.
      b. Continue final treatment of formed surface uniformly across the top of the unformed surface.
   2. Pavements and Sidewalks:
      a. The surface of the concrete shall be screeded to grade and sloped to drain. After screeding, the surface shall be Float Finished followed by a Broom Finish.
      b. Round edges and expansion joints to a radius of 1/2 inch. Control joints shall be grooved or sawcut to a minimum depth of 1/4 the slab thickness.

3.17 FIELD SAMPLING AND TESTS

A. General:
   1. Field sampling and tests shall be performed by an independent testing laboratory. Samples of aggregates and concrete will be obtained at such times to represent the quality of the materials and work throughout the project.
   2. The laboratory shall provide necessary labor, materials and facilities for sampling aggregate and for casting, handling, and initially storing the concrete samples at the work site.
   3. The minimum number of samples and tests are specified in Testing paragraph below.

B. Sampling:
    1. Aggregates:
        a. General:
            1) Sample fine and coarse aggregates in accordance with ASTM D75 not less than 30 days prior to the use of such aggregates in the work.
            2) Take samples at the discharge gates of the bins feeding the weigh hopper. Repeat sampling when the source of material is changed or when unacceptable deficiencies or variations from the specified requirements of materials are found.
            3) Aggregate samples shall be tagged and their sources identified.
        b. Coarse Aggregate:
            1) Take a sample weighing between 50 and 60 pounds after the batch plant is brought up to full operation.
            2) Take samples to obtain a uniform cross section, accurately representing the materials on the belt or in the bins for sieve analysis.
        c. Fine Aggregate:
            1) Take samples as specified for coarse aggregate.
            2) Take samples of sand when the sand is moist for sieve analysis and specific gravity tests.
    2. Concrete:
        a. Take samples of plastic concrete in accordance with ASTM C172.
        b. Take samples at the hopper of mixing equipment or transit mix truck, except as noted in the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

C. Testing:
    1. Aggregate:
        a. A minimum of one test of coarse aggregate per 400 cubic yards of concrete used and a minimum of one test of fine aggregate per 200 cubic yards of concrete used shall be made to confirm continuing conformance with specifications for gradation, cleanliness and sand equivalent.
        b. A maximum of one test per day of each aggregate is required.
        c. Repeat of the entire concrete mix design test program is required before source changes will be accepted.
    2. Concrete:
        a. Strength Tests:
            1) The strengths specified for the design mix shall be verified by the independent testing laboratory during placement of the concrete. Verification shall be accomplished by testing standard cylinders of concrete samples taken at the job site. Cylinders shall be 4 by 8 inch or 6 x 12 inch.

2) Concrete samples shall represent the concrete placed in the forms. One set of six standard 6 x 12 inch (or nine 4 x 8 inch) cylinders shall be cast of each class of concrete for each 150 cubic yards or less, or for each 5,000 square feet of slab or wall surface area placed per day. Provide additional cylinders when an error in batching is suspected. Each set of cylinders are cast from material taken from a single load of concrete.
3) Casting, handling and curing of cylinders shall be in accordance with ASTM C31. For the first 24 hours after casting, keep cylinders moist in a storage box constructed and located so that its interior air temperature will be between 60 and 80 degrees F. At the end of 24 hours, the testing laboratory will transport the cylinders to their laboratory.
4) Testing of specimens for compressive strength shall be in accordance with ASTM C39. Each test shall consist of two 6 x 12 inch (or three 4 x 8 inch) test cylinders from each group of six (or nine) specimens. Test at the end of 7 days and at the end of 28 days. The remaining cylinders shall be tested at the end of 56 days if the 28-day strength reports below specification.
5) A strength test shall consist of the average strength of two 6 x 12 inch (or three 4 x 8). If one cylinder shows evidence of low strength due to improper sampling, casting, handling, or curing, the result of the remaining cylinders may be used if approved by the Owner's Representative.
6) The average of any three consecutive 28-day strength test results of the cylinders representing each class of concrete for each structure shall be equal to or greater than the specified strength. Not more than 10 percent of the individual strength test results shall have values less than the specified 28-day strength for the total job concrete. No individual strength test result shall be less than the specified strength by more than 500 pounds per square inch.
7) Provide certified reports of the test results directly to the Owner's Representative and the Engineer. Test reports shall include sufficient information to identify the mix used, the stationing or location of the concrete placement, and the quantity placed. Slump, water/cement ratio, air content, temperature of concrete, and ambient temperature shall be noted.
8) The 28-day strength test results shall be evaluated in accordance with ACI 214R. Quality control charts showing field test results shall be included with the test results for each class of concrete in each major structure. Charts shall be prepared in accordance with ACI 214R. Quality control charts shall be maintained throughout the entire project and shall be available for the Owner's Representative's inspection at any time.
9) If the 28-day test results fall below the specified compressive strength for the class of concrete required for any portion of the work, adjustment in the proportions, water content, or both, shall be made as necessary at the Contractor's expense. Report changes and adjustments in writing to the Owner's Representative.

10) If compressive test results indicate concrete in place may not meet structural requirements, tests shall be made to determine if the structure or portion thereof is structurally sound. Tests may include, but not be limited to, cores in accordance with ASTM C42 and any other analyses or load tests acceptable to the Engineer. Costs of such tests and/or analysis shall be borne by the Contractor.

b. Tests for Consistency of Concrete:
   1) Measure slump in accordance with ASTM C143. Take samples for slump determination from concrete during placement. Tests shall be made at the beginning of concrete placement operation, whenever test cylinders are cast, and at subsequent intervals to ensure that the specification requirements are met.
   2) For pumped concrete, measure slump in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.
   3) When high range water reducer is added at the site, slump tests shall be taken before and after addition of the admixture.

c. Tests for Temperature and Air Content:
   1) Temperature tests shall be made at frequent intervals during hot or cold weather conditions until satisfactory temperature control is established. Perform temperature tests whenever test cylinders are cast.
   2) Measure air content in accordance with ASTM C231 whenever test cylinders are cast. For pumped concrete, measure air content in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

D. Final Laboratory Report:
   1. The testing laboratory shall provide a final report at the completion of all concreting. This report shall summarize the findings concerning concrete used in the project and provide totals of concrete used by class and structure.
   2. Include final quality control charts for compressive strength tests for classes of concrete specified in each major structure. Also include the concrete batch plant's coefficient of variation and standard deviation results for each class of concrete.

3.18 REPAIR OF DAMAGED AND CRACKED CONCRETE:

A. Acceptance Of Concrete:
   1. Completed cast-in-place concrete work shall conform to the applicable requirements of ACI 301 and the Contract Documents. Concrete work that fails to meet these requirements shall be repaired, as approved by the Engineer, to bring the concrete into compliance. Repair methods shall be in accordance with ACI standards, including ACI 503.7, and are subject to the approval of the Engineer.
   2. Concrete that cannot be brought into compliance by approved repair methods will be rejected. Remove and replace rejected concrete work.
   3. The cost of repairs and replacement of defective concrete shall be borne by the Contractor.

B. Repair Methods:
   1. Damaged/defective concrete or concrete with crack widths exceeding 0.004 inches at liquid-containing and conveying structures or crack widths exceeding 0.006 inches for other structures shall be repaired by one of the following methods (only the Engineer may determine that a defect or crack does not require repair):
      a. Perform watertightness testing and repair as needed to meet leakage criteria in this specification even when liquid-containing and conveying structures meet the crack width criteria defined above.
      b. Damaged or defective concrete includes surface defects, honeycomb, rock pockets, indentations greater than 3/16 inch, spalls, chips, air bubbles greater than 1/2 inch diameter, pinholes, bugholes, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints, fins, projections, form popouts, texture irregularities, and stains or other color variation that cannot be removed by cleaning.
         1) Damaged or defective concrete is repaired according to procedures outlined above under finish requirements, Repair of Surface Defects.
   2. Crack Repair Method 1:
      a. Fill the joint or crack by drilling holes to the affected area (following the product manufacturer's details), install injection ports, and force epoxy or chemical grout (expanding urethane) into the joint under pressure.
      b. Material type and repair procedures shall be approved by Engineer.
      c. After injection and curing; ports, sealing mix, and surface shall be cleaned and worked to match the adjacent specified finish.
   3. Crack Repair Method 2:
      a. Fill cracks with low viscosity epoxy, applied by pouring/flooding crack zone until cracks are filled. Prepare surface, install, and cure according to manufacturer's recommendations.
      b. At a minimum, prepare surface to be clean and dry with no visible detrimental material in cracks to be filled. Conform to temperature limitations of epoxy. Clean and refinish to match adjacent surfaces.
   4. Crack Repair Method 3:
      a. Cut a bevel groove 3/8 to 1/2 inch in width and depth, use backer rod or tape, and fill with sealant in accordance with manufacturer's instructions.
      b. This repair method is only used where approved by Engineer.
      c. Groove and sealant shall be applied on wet or hydrostatic pressure side of surface.

C. Repair Method Use:
   1. Repair Method 1: For cracks in walls, surfaces sloped 1:1 or greater, beams, columns, structural slabs, overhead surfaces, and liquid retaining surfaces. Need for repair depends upon crack width, location, and leakage.
   2. Epoxy grout is used for repair of structural cracks and chemical grout (expanding urethane) for repair of non-structural cracks at liquid-containing structures. The Engineer shall determine whether a crack is classified as structural or non-structural.
   3. Repair Method 2: Utilized in lieu of Method 1 for slabs when approved by Owner's Representative. Final finish shall match adjacent surfaces.

4. Repair Method 3: Limited to dry-surface slabs, walls subject to less than three feet of liquid pressure, or as approved by Engineer. Repair Method 3 is not an equivalent repair method to Repair Methods 1 or 2, which shall be considered the standards.

3.19 BEARING AND SEAL PADS

A. General:
   1. Seal pads are intended to result in a gas-tight and liquid tight seal between surfaces and may also serve as bearing pads. Bearing pads are intended primarily to transmit structural loads between two structural elements.
   2. A seal pad is intended to seal by dead load compressive force or mechanical clamping force as detailed. The seal pad may be bonded to one or both surfaces to maintain uniformly tight contact with the pieces contacting it. Neoprene materials may not be compatible with coatings applied later, and the Contractor shall verify that the particular coating(s) proposed for use are:
      a. contact compatible without neoprene breakdown; or
      b. mask off neoprene which may be exposed to the coating to prevent contact.

B. Concrete Contact:
   1. Neoprene pads shall bear against clean, smooth concrete. Clean concrete with high-pressure hydro-blast (3,500 psi) equipment. Epoxy grout cracks as specified above. Repair surfaces with irregularities greater than 1/16 inch. Create a 1/4-inch amplitude surface roughness and patch using an epoxy bonding agent followed by either polymer modified repair concrete or profiling mortar. Cure patch material before installing pad.
   2. Bond seal pad, as indicated, to concrete prepared as above. Bonding agent shall be as recommended by the pad manufacturer to not allow shear sliding of the pad either with or without load normal to its surface.

C. Metal Surface Contact:
   1. Neoprene pads with metal-to-metal or metal-to-concrete contact shall be 1/4 inch minimum thickness or as shown on the drawings.
   2. Contact surfaces shall be clean, smooth, and without evidence of harmful sharp edges or chemicals.
   3. Compression is achieved by tightening connection bolts to specified torque, determined by:
      a. the equipment manufacturer; or
      b. structural specifications on the drawings; or
      c. minimum 1/16 turn past “snug tight” as defined by AISC Steel Construction Manual.
   4. Tighten bolts in multiple steps, proceeding around the joint to result in a uniform compression of the pad.
   5. Certain pieces of equipment may have gasket specifications particular to that piece of equipment. Refer to those Sections of the specifications for requirements.

3.20 WATERTIGHTNESS TESTING AND REPAIR

A. Liquid Containing Concrete Tanks And Channels:

1. Watertightness testing shall comply with ACI 350.1 and the following requirements.
2. Concrete tanks, basins, reservoirs and channels which have walls or slabs subjected to hydrostatic pressure shall be tested for watertightness. The tests shall be made after the structure is complete and the concrete has achieved its specified 28-day strength, but prior to application of waterproof coating or backfill.
3. Filling of the tank for watertightness testing shall not exceed a rate of 4 feet/hour. Fill with water to the maximum operating water surface. Keep water at this level for at least 72 hours prior to start of test.
4. Testing includes visual inspection of the dry sides of all walls, wall base construction joint at top of the slab, and the soffit of elevated slabs for evidence of leakage. Damp spots, leakage, or seepage revealed by the test, including those caused by shrinkage of concrete, honeycombed areas, construction joints, or other sources shall be repaired by Repair Method 1 (see Repair Methods paragraph in the Repair of Damaged Concrete and Cracking article above).
5. Damp spots are defined as areas from which water that can be picked up on dry hand and smeared across the dry concrete surface.
6. Re-test tanks or channels which have been repaired to check the suitability of repairs.
7. Provide water required for testing and re-testing and dispose of in an approved manner.
8. After repair of visual leakage, liquid containing or conveying concrete structures supported on soil must also meet maximum leakage criteria into the soil through their base slab or mat foundation as follows:

Structure Type	Tightness Criterion
Containment structures fully lined prior to hydrostatic test	No measurable loss
Cylindrical water and wastewater storage tanks and reservoirs other than digesters	0.050 percent per day
Digesters	0.050 percent per day (surcharged hydrostatic test)
Rectangular basins and tanks	0.050 percent per day
Concrete paved reservoirs and channels	0.10 percent per day

Note: All damp spots and/or leakage through walls, wall-to-slab joints, and elevated slabs shall first be repaired as described above.

9. Record volume loss by measuring the vertical distance from the water surface to a fixed point on the tank above the water surface. Account for evaporation from open surfaces.
10. If the drop in water surface during the test period exceeds the values given in the table above, exclusive of evaporation, the leakage is considered excessive and shall be remedied. The test period shall be per ACI 350.1.

3.21 CLEANUP

A. Upon completion of the work and prior to final inspection, clean all concrete surfaces as follows: Sweep with a broom to remove loose dirt, then mop and/or flush with clean water. Scrub by hand or machine as required to remove and blend stains or discolored areas .

B. Clean floors that have curing and sealing compound as stated above, followed by the final application of curing and sealing compound.

END OF SECTION

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SECTION 03 30 10

CAST-IN-PLACE CONCRETE TOPPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast-in-place concrete topping replacement at existing clarifiers, which includes dewatering site, removal of existing topping, preparation of surfaces, providing material, mixing, equipment, and labor for the proportioning, mixing, transporting, testing, placing, consolidating, finishing, curing, and protection of concrete topping.

B. Contractor provided testing laboratory services.

C. Groundwater is normally high in this area. Project includes dewatering immediate site around clarifiers to prevent floatation.

D. New concrete topping to be “swept-in” using existing clarifier equipment with temporary scraper blades installed by Contractor.

1.02 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 211.1	Selecting Proportions for Normal, Heavy Weight and Mass Concrete
ACI 301	Specifications for Structural Concrete
ACI 305.1	Specification for Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 214R	Guide to Evaluation of Strength Test Results in Concrete
ACI 318	Building Code Requirements for Structural Concrete
ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C33	Concrete Aggregates
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C94	Ready-Mixed Concrete
ASTM C117	Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Slump of Hydraulic Cement Concrete
ASTM C150	Portland Cement
ASTM C157	Length Change of Hardened Cement Mortar and Concrete
ASTM C172	Sampling Freshly Mixed Concrete
ASTM C192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Air-Entraining Admixtures for Concrete

Reference	Title
ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Chemical Admixtures for Concrete
ASTM C595	Blended Hydraulic Cements
ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Slag Cement for use in Concrete and Mortars
ASTM C1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1315	Liquid Membrane-Forming Compounds for Curing and Sealing Concrete
ASTM C1567	Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate
ASTM C1602	Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Sampling Aggregates
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM E329	Agencies Engaged in Construction Inspection and/or Testing
IBC	International Building Code with local amendments

1.03 SUBMITTALS

A. Action Submittals:
   1. Mix design showing:
      a. Expected strength at 7 and 28-days
      b. Water/cement ratio
      c. Weights and test results of ingredients
      d. Aggregate gradation
      e. Test results of mix design prepared by an independent testing laboratory
      f. Other physical properties necessary to review mix design for conformance with these specifications
   2. Product literature and technical data for cement and pozzolan.
   3. Product literature, technical data, and dosage of proposed admixtures including, but not limited to, air entraining, water reducing, retarding, etc.
   4. Curing program description in sufficient detail to demonstrate that the Contractor will provide acceptable strength, finish, and crack control.
   5. Product literature and technical data for bonding and curing compounds.
   6. Concrete delivery truck tickets showing the information listed in ASTM C94.

1.04 QUALITY ASSURANCE

A. Quality Control By Contractor:
   1. To demonstrate conformance with specified requirements of this section, provide services of an independent testing laboratory which complies with requirements of ASTM E329. The testing laboratory shall sample and test concrete materials as specified in this section.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:
   1. Portland cement shall be ASTM C150, Type II, low alkali, containing less than 0.60 percent alkalis. In addition to standard requirements, cement shall satisfy optional chemical and physical requirements of ASTM C150, Tables 2 and 4, respectively.
   2. Blended Hydraulic Portland- cement shall be ASTM C595, Type IL (MS).
   3. If low alkali cement is not available, aggregates shall show an expansion of less than 0.1% when tested in accordance with ASTM C1260 or ASTM C1567 concrete mix test results shall be submitted verifying that aggregates are not reactive. ASTM C1260 and ASTM C1567 results shall be no older than 1 year.
   4. Use cementitious materials that are of the same brand and type and from the same plant of manufacture as the cementitious materials used in the concrete represented by the submitted field test records or used in the trial mixtures.

B. Ground granulated blast-furnace slag (GGBFS), if used in conjunction with Portland cement, shall be per ASTM C989.

C. Aggregates:
   1. General:
      a. Except as modified herein, fine and coarse aggregates shall conform to ASTM C33. Fine and coarse aggregates are regarded as separate ingredients. Aggregates shall be non-reactive and washed before use.
      b. Check aggregates for alkali-silica reactive constituents per ASTM C1260. Aggregate shall have less than 0.1% expansion when tested in accordance with ASTM C1260. Aggregates having 0.1% or greater expansion may still be satisfactory provided ASTM C1567 concrete mix test results are submitted and show an expansion of less than 0.1% at 16 days. Test results shall be no older than 1 year.
      c. Test for size and grading of fine and coarse aggregates in accordance with ASTM C136.
      d. Aggregates used in the project production concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by the submitted historical data or trial mixtures.
   2. Fine Aggregate:
      a. Fine aggregate shall be hard, dense, durable particles of either sand or crushed stone regularly graded from coarse to fine. Gradation shall conform to ASTM C33.
   3. Coarse Aggregate:
      a. Coarse aggregate shall be hard, dense and durable gravel or crushed rock free from injurious amounts of soft and friable particles, alkali, and organic matter. Other deleterious substances shall not exceed the limits listed in ASTM C33, Table 3 for Class Designation 5S. Gradation of coarse aggregate size specified shall conform to ASTM C33, Table 2.

D. Pozzolan:
   1. Pozzolan shall be Class N, natural pozzolan, or Class F fly ash conforming to ASTM C618. Class C fly ash is not allowed.
   2. Use pozzolan materials that are of the same brand and type and from the same plant of manufacture as the materials used in the concrete represented by the submitted field test records or used in the trial mixtures.

E. Admixtures:
   1. General:
      a. Admixtures shall be compatible with the concrete and with each other. Calcium chloride or admixtures containing calcium chloride are not acceptable. Use admixtures in accordance with the manufacturer's recommendations and add separately to the concrete mix.
   2. Water Reducing Admixtures:
      a. Conform to ASTM C494, Type A. Acceptable products include: BASF "MasterPozzolith 322"; SIKA Chemical Corp. "Plastocrete 161"; Euclid Chemical Co. "Eucon WR 91"; or approved equal.
   3. Water Reducing and Retarding Admixtures:
      a. Conform to ASTM C494, Type D. Acceptable products include: BASF "MasterPozzolith 80"; Sika Chemical Corp. "Plastiment"; Euclid Chemical Co. "Eucon Retarder 75"; or approved equal.
   4. High Range Water Reducing (Superplasticizing) Admixtures:
      a. Conform to ASTM C494, Type F. Acceptable products include: BASF "MasterGlenium" Series; Sika Chemical Corp. "Viscocrete 2100" or "Viscocrete 2110" (Hot Weather) or "Viscocrete 6100" (Cold Weather); Euclid Chemical Co. "Eucon 37"; W.R. Grace "ADVA 195"; or approved equal.
   5. High Range Water Reducing And Retarding Admixtures:
      a. Conform to ASTM C494, Type G. Acceptable products include: W.R. Grace "Daracem 100"; Sika Chemical Corp. "Sikaplast 200"; Euclid Chemical Co. "Eucon 537"; or approved equal.
   6. Air Entraining Agent:
      a. Conform to ASTM C260 and produce air entrained concrete as specified in the Mix Proportioning table below. Acceptable products include: Sika Chemical Corp. "AEA-15"; Euclid Chemical Co. "AEA-92"; or approved equal.

F. Water:
   1. For washing aggregate, mixing, and for curing shall be free from oil and deleterious amounts of acids, alkalis, and organic materials; comply with the requirements of ASTM C1602. Additionally, water used for curing shall not contain an amount of impurities sufficient to discolor the concrete.

2.02 CONCRETE CHARACTERISTICS

A. Mix Proportioning:

1. Concrete topping shall be normal weight concrete composed of cement, pozzolan, admixtures, aggregates, and water; proportioned and mixed to produce a workable, strong, dense, and impermeable concrete. It is acceptable to substitute interground Portland-pozzolan cement conforming to ASTM C595, containing the specified amount of pozzolan in lieu of Portland cement and pozzolan. Water-cementitious material (w/cm) ratio is based on the combined contents of cement and pozzolan.

2. Provide concrete mix design in accordance with the following guidelines:

Concrete Class	Minimum[a] 28-day Compressive Strength, psi	ASTM Coarse Aggregate Size	Maximum Water-Cementitious Materials (w/cm) ratio	Minimum Cementitious Materials Content (pounds/CY)	Pozzolan, Percent by weight of Cementitious Materials	Air Content (percent)	Slump range[c] (inches)
D-1	4000	3/8	0.42	550	15-20[b]	4-6	3-5

[a] *Determine compressive strength at the end of 28 days based on test cylinders made and tested in accordance with ASTM C39.*

[b] *Pozzolan use is optional.*

[c] *Slump before addition of high range water reducing admixture (superplasticizer). Maximum slump after addition of high range water reducing admixture shall be 8".*

B. Control Tests:

1. General:
   a. Select and adjust proportions of ingredients in accordance with ACI 211.1. Verification of mix characteristics for submittal may be achieved using either the Trial Mix Design method or Field Experience Data method.
   b. Do not place concrete prior to submittal and acceptance of proposed mix.
2. Trial Mix Design:
   a. Mixes verified by this method shall have the samples produced for testing, manufactured at the batch plant which will supply concrete to the project, using materials proposed for the Work and material combinations listed above. Testing, data, and reporting shall conform to ACI 318 and the following:
      1) Required compressive strength used as the basis for selecting concrete proportions (f'cr) shall be the specified concrete strength (f'c) + 1200 psi.
      2) Make at least three different trial mixtures for concrete to be qualified by the Trial Mix Design. Each trial mixture shall have a different w/cm ratio or different cementitious materials content that will produce a range of compressive strengths encompassing f'cr.
      3) Design trial mixtures to produce a slump within ¾ inch of the maximum specified and an air content within 0.5 percent of the maximum specified.
      4) For each w/cm ratio or cementitious materials content, cast and cure at least twelve standard test cylinders in accordance with ASTM C192. Four cylinders from each batch tested at age 7-days, 14-days, and 28-days or as required to comply with ACI 318.

5) From results of the cylinder tests, plot a curve showing the relationship between w/cm ratio and compressive strength.

6) From the curve of w/cm ratio versus compressive strength, select the w/cm ratio that will produce f'cr. This is the maximum w/cm ratio to be used unless a lower w/cm ratio is specified above.

3. Field Experience Data:

a. When sufficient test data for the mix design is available which is identical or substantially similar to that proposed for use, Contractor may substitute use of this data in lieu of a trial mix design. Field data, reports, and analysis shall conform to ACI 318, except as modified herein.

1) Historical mix design proportions for which data are submitted may vary from the specified mix within the following limits:

a) f'c as specified or up to 500 psi above

b) w/cm ratio as specified or lower

c) pozzolan content within 5 percent of that specified

d) maximum coarse aggregate size may not vary smaller, but gradation of coarse aggregate may vary

e) slump after introduction of admixtures +0/-1 inch.

b. Use of historical Field Experience Data does not allow modification of the project mix specifications herein without review and acceptance by the Engineer.

c. Do not place concrete prior to acceptance of the concrete mix.

2.03 EPOXY BONDING COMPOUND

A. Conform to ASTM C881 Types IV or V, Class A, B, or C depending on temperature at use. Acceptable products include: BASF "MasterEmaco ADH 327RS" or "MasterEmaco ADH 1490"; Sika Chemical Corporation "Sikadur 32"; or approved equal.

B. Apply bonding compound in accordance with the manufacturer's instructions.

2.04 CURING AND SEALING COMPOUND

A. Conform to ASTM C309 and ASTM C1315. Acceptable products include: BASF "MasterKure CC 250SB"; Dayton Superior "Cure & Seal 25% J22UV"; or approved equal.

B. Compound shall be clear and applied in accordance with the manufacturer's instructions but apply at twice the standard application rate.

PART 3 EXECUTION

3.01 GENERAL

A. Use only truck-mixed, ready-mixed concrete conforming to ASTM C94. Proportion materials by weighing.

B. Introduce pozzolan into the mixer with cement and other components of the concrete mix; do not introduce pozzolan into a wet mixer ahead of other materials or with mixing water.

C. Introduce water at the time of charging the mixer; additional water may be introduced within 45 minutes from charging the mixer, provided the specified w/c ratio and slump is not exceeded and the maximum total water per the approved mix design is not exceeded.

D. Arrange with the testing laboratory for inspection and testing.

E. Deliver concrete to the site and complete discharge within 90 minutes after introduction of water to the mixture. Extension of allowable time beyond this limit requires a Contractor proposed remedial action plan to be reviewed and accepted by the Owner's Representative.

3.02 CONVEYING AND PLACING CONCRETE TOPPING

A. Convey concrete from the mixer to the clarifier base slab in accordance with ACI 301.

B. Placing Concrete:
   1. General:
      a. Place concrete in accordance with ACI 301. Do not permit concrete to drop freely more than 4-ft.
   2. Placing Concrete By Pumping:
      a. Concrete topping placed by pumping is at Contractor's discretion and shall not be cause to change or relax specified mix design characteristics. Concrete shall possess the specified characteristics at the point of placement.
      b. Measure slump at the hose discharge, except as follows: Initial slump testing in each placement shall occur at both the pumping unit inlet hopper and hose discharge. Slump loss in pumping, measured between the inlet hopper and the hose discharge, shall not exceed 1 inch. After these criteria have been satisfied, slump may be measured at the inlet hopper with allowable slump increased by the earlier measured difference, not to exceed 1 inch.
      c. Measure air content at the hose discharge, except as follows: Initial air content testing shall occur at both the pumping unit inlet hopper and the hose discharge. Loss of air content shall be measured between the inlet hopper and the hose discharge. Increase the air content of the delivered concrete at the inlet hopper to provide the specified air content at the hose discharge. After these criteria have been satisfied, air content may be measured at the inlet hopper.
   3. Placing Concrete In Hot Weather:
      a. In temperatures above 80 degrees F, place concrete in accordance with ACI 305.1.
   4. Placing Concrete In Cold Weather:
      a. In temperatures below 45 degrees F, place concrete in accordance with ACI 306.1.

3.03 CONSOLIDATE CONCRETE:

A. In accordance with ACI 301.

3.04 CURING

A. General:
   1. Cure concrete topping using water, a membrane curing compound, or by a combination of both methods.
   2. Maintain concrete surface temperature between 50 degrees F and 80 degrees F for at least 5 days. Cure concrete in hot weather (above 80 degrees F) in accordance with ACI 305.1. Cure concrete in cold weather (below 45 degrees F) in accordance with ACI 306.1.

B. Water Curing:
   1. Keep concrete continuously wet for a minimum of 10-days after placement. Absorptive mats or fabric may be used to retain moisture during the curing period.
   2. Use water curing in hot weather. Cover surface and keep moist.

C. Curing Compound:
   1. When curing compound is allowed, apply it as soon as the concrete has set sufficiently so as not to be marred by the application. Preparation of surfaces, application procedures, and installation precautions shall follow manufacturer's instructions.
   2. Apply curing compound at twice the manufacturer's recommended dosage rate, applied in two coats perpendicular to each other.

3.05 PROTECTION

A. Protect concrete topping from injurious action by sun, rain, flowing water, frost, and mechanical means.

B. Arrangements for covering, insulating, heating, and protecting concrete in cold weather shall be in accordance with ACI 306.1.

3.06 CONSTRUCTION JOINTS

A. Place concrete topping continuously without joints.

3.07 PREPARATION OF EXISTING CONCRETE

A. Bonding of New Concrete Topping To Existing Slab:
   1. Remove entire existing grout/concrete topping.
   2. Roughen existing concrete slab surface by abrasive blasting, bush hammering, or other method to achieve ¼-inch amplitude surface. Clean prepared surface.
   3. Coat existing surface with epoxy bonding compound immediately prior to placement of new concrete topping. As an alternate, wet concrete slab surface to a saturated, surface dry condition, apply a cement paste (topping mix without course aggregate) and scrub the paste into the existing surface using stiff brooms. Immediately apply concrete topping prior to drying of the scrub coat paste.

3.08 CONCRETE TOPPING FINISH

A. General:
   1. Do not use dry cement on new concrete surfaces to absorb excess moisture.
   2. Immediately after final finish is applied, the surface shall be cured and protected as specified above.

B. Float Finish:
   1. Apply float finish to concrete topping by final spreading and truing of the topping using the clarifier equipment. “Sweep-in” the concrete topping by first changing out the existing clarifier mechanism scraper blades with a similar temporary blade as recommended by the equipment manufacturer for this use.
   2. After “sweeping-in” the concrete topping, wait and begin final floating when the bleed water sheen has disappeared and the surface has stiffened sufficiently.
   3. Floating shall close cracks and checks plus compact and smooth the surface. Float the concrete topping to a uniform texture using the existing clarifier mechanism.

3.09 FIELD SAMPLING AND TESTS

A. General:
   1. Field sampling and tests shall be performed by the Contractor’s independent testing laboratory. Samples of aggregates and concrete will be obtained at such times to represent the quality of the materials and work throughout the project.
   2. The laboratory shall provide necessary labor, materials and facilities for sampling aggregate and for casting, handling, and initially storing the concrete samples at the work site.
   3. The minimum number of samples and tests are specified below.

B. Sampling:
   1. Aggregates:
      a. General:
         1) Sample fine and coarse aggregates in accordance with ASTM D75 not less than 30 days prior to the use of such aggregates in the work.
      b. Coarse Aggregate:
         1) Take a sample weighing between 50 and 60 pounds after the batch plant is brought up to full operation.
         2) Take samples to obtain a uniform cross section, accurately representing the materials on the belt or in the bins for sieve analysis.
      c. Fine Aggregate:
         1) Take samples as specified for coarse aggregate.
         2) Take samples of sand when the sand is moist for sieve analysis and specific gravity tests.
   2. Concrete:
      a. Take samples of plastic concrete in accordance with ASTM C172.
      b. Take samples at the hopper of transit mix truck, except as noted in the Placing Concrete by Pumping article above.

C. Testing:
    1. Aggregate:
        a. Repeat of the entire concrete mix design test program is required before source changes will be accepted.
    2. Concrete:
        a. Strength Tests:
            1) Verify the strength specified for the design mix by the independent testing laboratory during placement of the concrete topping. Verification shall be accomplished by testing standard cylinders of concrete samples taken at the job site. Cylinders shall be 4 x 8 inch or 6 x 12 inch.
            2) Concrete samples shall represent the concrete placed. One set of six standard 6 x 12 inch (or nine 4 x 8 inch) cylinders shall be cast for each clarifier topping. Provide additional cylinders when an error in batching is suspected. Each set of cylinders are cast from material taken from a single load of concrete.
            3) Casting, handling, and curing of cylinders shall be in accordance with ASTM C31.
            4) Testing of specimens for compressive strength shall be in accordance with ASTM C39. Two standard cylinders (three 4 x 8) tested at 7-days and two standard cylinders (three 4 x 8) tested at 28-days. The remaining cylinders are held in reserve.
            5) A strength test consists of the average strength of two 6 x 12 inch (three 4 x 8). If one cylinder shows evidence of low strength due to improper sampling, casting, handling, or curing, the result of the remaining cylinders may be used if approved by the Owner's Representative.
            6) The 28-day strength test results of the cylinders representing the concrete topping at each clarifier shall be equal to or greater than the specified strength. Individual strength test result shall not be less than the specified strength by more than 500 pounds per square inch.
            7) Provide certified reports of the test results directly to the Owner's Representative and Engineer. Test reports shall include sufficient information to identify the mix used, the stationing or location of the concrete placement, and the quantity placed. Slump, water/cement ratio, air content, temperature of concrete, and ambient temperature noted.
        b. Tests for Consistency of Concrete:
            1) Measure slump in accordance with ASTM C143. Take samples for slump determination from concrete during placement. Tests shall be made at the beginning of concrete placement operation, whenever test cylinders are cast, and at subsequent trucks to ensure that the specification requirements are met.
            2) For pumped concrete, measure slump in accordance with the Placing Concrete by Pumping article above.
            3) When high range water reducer is added at the site, slump tests shall be taken before and after addition of the admixture.

c. Tests for Temperature and Air Content:
    1) Temperature tests shall be made at frequent intervals during hot or cold weather conditions until satisfactory temperature control is established. Perform temperature tests whenever test cylinders are cast.
    2) Measure air content in accordance with ASTM C231 whenever test cylinders are cast. For pumped concrete, measure air content in accordance with the Placing Concrete by Pumping article above.

3.10 CLEANUP

A. Upon completion of the work and prior to final inspection, clean concrete surfaces as follows: Sweep with a broom to remove loose dirt and debris, then flush with clean water.

B. Coordinate dewatering activity with Owner until clarifier is returned to service.

END OF SECTION

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SECTION 03 48 11

PRECAST CONCRETE VAULTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Factory design and manufacture of precast concrete vault sections and accessories.

B. Quality assurance and control.

C. Field installation of vaults.

D. Waterproofing and epoxy coating of vaults.

E. Installation of frames, hatches, and fall protection.

F. Ladders and safety devices.

G. Vault schedule.

1.02 RELATED SECTIONS

A. Section 03 11 00 - Concrete Forming

B. Section 03 20 00 - Concrete Reinforcement

C. Section 03 30 00 - Cast-In-Place Concrete

D. Section 05 50 00 – Metal Fabrications

E. Section 08 31 20 – Floor Access Doors

1.03 REFERENCES

Reference	Title
ASTM C150	Portland Cement
ASTM C207	Hydrated Lime for Masonry Purposes
ASTM C478	Precast Reinforced Manhole Sections
ASTM C858	Underground Precast Concrete Utility Structures
ASTM C913	Precast Concrete, Water, and Wastewater Structures
ACI 301	Specifications for Structural Concrete Buildings
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 315R	Manual of Engineering and Placing Drawings for Reinforced Concrete Structures
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Environmental Engineering Concrete Structures
CRSI 63	Recommended Practice for Placing Reinforcing Bars

1.04 DESIGN

A. All vaults shall be designed by a licensed professional engineer registered in the State of Utah, and engaged by the manufacturer. All dead loads, live loads, flotation, erection, temperature and anchorage stresses shall be considered.

B. The calculations and drawings shall be prepared in a neat and legible manner, sealed by the licensed Professional Engineer performing the calculations.

C. The sealed calculations shall include a summary page to list all design loads, material specifications, and design criterion used in the calculations.

D. For design, groundwater shall be assumed at grade and the design shall provide for a 125 percent factor of safety against floatation.

E. Vaults shall be designed for H-20 wheel load on top slab, hatches, and surcharge loading at grade around all sides of the vault.

1.05 SUBMITTALS

A. Submit evidence that shows current PCI, NPCA, and/or DOT certification.

B. Submit shop drawings of wall sections and bases proposed for this project, include joint design and related details for field assembly as applicable.

C. Submit certification of conformance with Contract Documents and ASTM C478, C858, and C913.

D. Submit catalog cut and installation details for cast iron manhole covers, aluminum hatches with fall protection grates, and ladders with safety devices

E. Submit catalog cut for epoxy coating system used at interior surfaces and waterproofing system used on exterior surfaces.

F. Under a separate submittal, provide two file copies of calculations for each vault indicating all loads and load combinations. Other than the summary page, calculations will not be reviewed; calculations will not be returned to Contractor.

1.06 QUALITY ASSURANCE

A. Manufacturer shall be a PCI, NPCA, and/or DOT-certified plant for production of precast vaults as specified herein.

B. Aggregate used in producing concrete shall be from DOT approved sources.

1.07 QUALITY CONTROL INSPECTION

A. The quality of all materials, the process of manufacture and the finished sections shall be subject to inspection by Engineer. Such inspection may be made at the place of manufacture and/or at the Site after delivery.

B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close-textured and free of honeycomb, cracks, roughness, exposure of reinforcement, damaged joints, or other irregularities.

C. All sections which have been damaged after delivery will be rejected, or if already installed, shall be repaired or removed and replaced entirely at Contractor's expense.

D. Rejected sections shall be tagged as such, segregated from other sections, and removed from the Site.

PART 2 PRODUCTS

2.01 CONCRETE

A. Reference Section 03 30 00.

2.02 REINFORCEMENT

A. Reference Section 03 20 00.

2.03 PRECAST OR CAST-IN-PLACE CONCRETE BASES

A. Design and manufacture of precast concrete bases shall conform to the requirements of this section and ASTM C478, C858, and C913. Cast-in-place concrete bases shall conform to Section 03 11 00 and Section 03 30 00.

B. Bases shall conform to the dimensions indicated on the Drawings or as required by design. The horizontal joint at the top of the base shall be compatible with that of the precast wall section.

C. Sumps shall be field constructed where shown on the Drawings. Walking surfaces shall be sloped to the sump, have a non-slip broom finish, and be sealed with a penetrating concrete sealer. Minimum concrete fill thickness at sumps shall be two inches.

2.04 PRECAST CONCRETE WALLS

A. Design and manufacture of precast concrete walls shall conform to the requirements of this section and ASTM C478, C858, and C913.

B. All tongue-and-groove joints in the precast wall, including the joint at the top of the base, shall be made up using gaskets.

C. The precast sections shall be provided with a special groove to receive and hold the gasket in position during joint assembly.

D. After joint assembly, the gap between sections shall be packed on the inside and outside with "Masterflow 713" by Master Builder; "Five Star Grout" by U.S. Grout Corp.; or equal, and shall be troweled smooth so that no projections remain on the inside. There shall be concrete to concrete bearing between the various sections. The gasket shall not support the weight of the section.

2.05 PRECAST CONCRETE SLAB TOPS

A. Precast reinforced concrete slab tops shall be manufactured in accordance with ASTM C478, C858, and C913. Openings and frames shall be provided for hatches where shown on the Drawings. Slab tops shall be set in a full bed of mortar.

B. Slab tops shall be crowned or sloped to drain, minimum 1/4 inch per foot.

C. Concrete slab tops shall receive a non-slip broom finish and a penetrating concrete sealer per Section 03 30 00.

2.06 GRATING TOPS

A. Where grated tops are shown on the Drawings, the Contractor shall supply fabricated grating frames to the precast manufacturer and coordinate the grating installation for a complete Project.

2.07 PIPE SEALS

A. Where polyethylene, plastic or PVC pipe is utilized, connections between vault and pipes shall be made with flexible rubber sleeves with stainless steel straps and bolts. Provide an elastomeric waterstop gasket where sleeve sizes are not commercially available.

B. The annular space around the pipe wall or sleeve shall be packed with “Masterflow 713” by Master Builders, “Five Star Grout” by U.S. Grout Corp.; or equal. Before the grout has set, Contractor shall recheck invert elevations of the pipe.

C. For steel or ductile iron pipe, provide a pipe sleeve sized to accept the pipe plus a modular mechanical seal such as Link Seal or equal.

2.08 HATCHES

A. Hatches shall be of the size and type shown on the Drawings and as described in Section 08 31 20.
   1. Aluminum single leaf, watertight gasketed floor hatch. Floor hatch shall be furnished with flush stainless steel hinges, aluminum stiffeners, and lockable slam latch. Hatches shall have extended aluminum frame to match concrete thickness with continuous anchor and shall be constructed of 1/4 inch minimum aluminum diamond pattern plate design.
   2. Hatches shall be provided with an auto-lock, hold-open device and torsion spring assembly. All hardware, including all parts of the latch and lifting mechanism assemblies, hold-open arms and guides, and all brackets, hinges, pins and fasteners shall be stainless steel or bronze.
   3. The hatches shall be designed for an H-20 wheel load. A 1-inch drain coupling shall be provided in hatch frame. Contractor to extend drain to exterior of structure or to sump pit at vaults intended to remain dry.
   4. At all hatches, provide a hinged aluminum grate fall-through protection system.

2.09 LADDER

A. Where shown on the Drawings, provide ladders as specified in Section 05 50 00.

B. Where shown on Drawings, provide ladder rungs made of cast iron or polypropylene with steel reinforcement. Rungs shall be either cast in place or drilled and adhesive grouted in the shop. Rungs are equally spaced at a maximum 12-inch spacing from the top of the base slab to the top of the top slab.

C. Install ladder rungs so that the distance from the rungs to the finished wall is 7 inches.

D. Provide aluminum or stainless steel ladder access safety post as specified in Section 08 31 20

2.10 OPENINGS AND INSERTS

A. All openings required in the concrete shall be reinforced with additional diagonal bars tied to each layer of wall or slab reinforcement.

B. Any required pipe sleeves, inserts, and wall openings shall be coordinated with mechanical requirements prior to casting the units.

2.11 WATERPROOFING

A. Around the exterior of all wall joints, apply the “Bituthene” primer and membrane waterproofing system by W.R. Grace Company, or equal.

B. Exterior wall surfaces shall be waterproofed using manufacturer’s standard two-coat system, specifically designed to waterproof the exterior of concrete surfaces in a below-grade submerged condition.

C. For the top slab and above-grade exposed side walls, the concrete shall be sealed as per Section 03 30 00.

2.12 EPOXY COATING

A. The interior surface of the wet well shall receive a factory applied epoxy coating. Apply at wall surfaces (full height) and ceiling.

B. Surfaces shall be abrasive blasted and allowed to cure a minimum of 28 days prior to application of epoxy coating system. Follow manufacture’s instructions for primer, application temperatures, etc. Use Sika Corporation “Sikagard 62”, Euclid Chemical Company “Duraltex 1707”, or equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that subgrade elevations for vault base is correct, excavation is dewatered, and subgrade is pre-compacted.

B. Verify that rejected units have been removed from Site.

3.02 PREPARATION

A. Provide foundation mat of run-of-crusher stone to support base. Mat shall be 6 inches minimum depth and shall bear on sound undisturbed earth; excavate and remove subgrade material as necessary to reach sound subgrade.

B. Stone foundation mat shall be a minimum of 1 foot greater than the footprint of the vault base, and shall be compacted to a uniform, level surface.

3.03 INSTALLATION

A. Vault shall be accurately located and uniformly supported on the foundation mat in a level position.

B. Install wall sections in properly oriented position; follow manufacturer's instructions for joining together each section using the gaskets. Pack joints with grout.

C. Units shall be laid-up plumb and level.

D. Contractor is responsible for the integrity of all materials and protection against flotation during the installation and backfilling process.

3.04 COATINGS

A. All exterior below-grade wall joints shall be sealed using a membrane waterproofing system. Next, all below-grade wall surfaces shall be waterproofed, applied per manufacturer's instructions.

B. After installation is complete, the cover slab and interior walking surfaces shall be sealed as specified above.

C. After installation of mechanical equipment, provide touch-up painting of damaged epoxy wall finish.

3.05 BACKFILLING

A. Backfill using well compacted structural fill material, being careful to not damage exterior waterproof coating while providing full support under connecting pipes using compacted bedding material.

B. During the one year warranty period, all visible leaks shall be sealed in an approved manner.

3.06 SCHEDULE OF VAULTS

Vault Identification	Reference Drawing
Perimeter Drain Pump Station	GM-05 Perimeter Drain Pump Station
Infiltration Gallery Pump Station	GM-04 Infiltration Gallery Pump Station

END OF SECTION

SECTION 03 60 00

GROUTING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Grout for column base plates, other structural supports, equipment bases, reinforcing bar dowels, surface repair, grout toppings, patching of fresh concrete, and uses other than masonry. Grout for masonry is specified in Section 04 20 00. Adhesive anchor bolt grouting is specified in Section 05 05 20.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete
   2. Section 04 20 00 Concrete Unit Masonry
   3. Section 05 05 20 Anchor Bolts
   4. Section 43 05 13 Rigid Equipment Mounts

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM C109	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm Cube Specimens)
ASTM C230	Flow Table for Use in Tests of Hydraulic Cement
ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
ASTM C939	Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C942	Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
ASTM C1181	Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection

Reference	Title
COE CRD-C611	Flow of Grout for Preplaced Aggregate Concrete
COE CRD-C621	Non-shrink Grout
IBC	International Building Code

1.04 SUBMITTALS

A. Action Submittals
   1. Procedure: Section 01 33 00:
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Complete product literature, including mixing, handling and placement instructions for the following: Cementitious non-shrink grout, epoxy grout, adhesive for reinforcing bar dowel grouting, concrete repair mortar, and prepackaged cement grout products to be used on the project.
   5. Mix design for cement grout that is not prepackaged, including product data for aggregates and cement in accordance with Section 03 30 00.
   6. Current ICC Evaluation Service reports for adhesives used for reinforcing dowels.
   7. Installer certification in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.
   8. Certified test results verifying the compressive strength, shrinkage and expansion requirements specified herein.

1.05 QUALITY ASSURANCE

A. Quality Control by Owner
   1. The Owner will provide the services of a qualified Special Inspector in accordance with Section 01 45 29.
   2. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
      a. The Special Inspector shall furnish a report to the Engineer, Owner's Representative and Building Official that the work covered by the report has been performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Quality Control by Contractor
   1. Provide the services of an independent testing laboratory which complies with the requirements of ASTM E329 if a product other than those listed below is proposed and test data is not available from the supplier to demonstrate equivalence to the specified grout. The testing laboratory shall sample and test the proposed grout materials. Costs of testing laboratory services shall be borne by the Contractor.

C. Certifications
   1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.

D. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications.
   1. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.
   2. 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 seven days, 28 days and any additional time period as appropriate.

E. Manufacturer Qualifications
   1. Manufacturer shall have a minimum of five years experience of producing products substantially similar to that required and shall be able to submit documentation of at least five satisfactory installations that have been in successful operation for at least five years each.
   2. When required, provide services of manufacturer's full-time employee, factory-trained in handling, use, and installing the products required, with at least five years of experience in field applications of the products required.

PART 2 PRODUCTS

2.01 CEMENTITIOUS NON-SHRINK GROUT

A. The grout material shall be an approved ready to use mixture requiring only water for use at the job site. The 2-inch cubes shall have a minimum compressive strength of 3,000 psi at 7 days and 7,000 psi at 28 days.

B. Cementitious non-shrink non-metallic aggregate grout shall be:
   1. BASF, Masterflow 928
   2. Euclid Chemical Company, Hi-Flow Grout
   3. Five Star Products, Inc., Five Star Grout
   4. Sika Corporation, SikaGrout 212
   5. Approved Equal

C. Non-shrink grout shall conform to CRD-C 621 and ASTM C1107, Grade B or C when tested at a maximum fluid consistency of 30 seconds per ASTM C939 at temperature extremes of 45 degrees Fahrenheit and 90 degrees Fahrenheit and an extended working time of 15 minutes.

D. Fluid grout shall pass through the flow cone, with continuous flow, one hour after mixing.

2.02 EPOXY GROUT FOR EQUIPMENT MOUNTING:

A. Epoxy grout shall be a pourable, non-shrink, 100-percent solids system.

B. Epoxy grout for equipment mounting shall be a non-cementitious, resin based, multi-component formulation. Epoxy grout shall be flowable, with shrinkage minimized to achieve minimum 98% effective bearing area. Epoxy grout shall be:
   1. BASF, Masterflow 648
   2. Euclid Chemical Company, E3-G
   3. Sika Corporation, Sikadur 42
   4. Approved Equal.

C. The following properties shall be attained with the minimum quantity of aggregate allowed by epoxy grout manufacturer.
   1. Length change after hardening shall be less than 0.0006-inch per inch and coefficient of thermal expansion shall be less than 0.00003-inch per inch per degree F when tested in accordance with ASTM C531.
   2. Compressive creep at one year shall be less than 0.001-inch per inch when tested under a 400-psi constant load at 140 degrees F in accordance with ASTM C1181.
   3. Minimum seven-day compressive strength shall be 14,000 psi when tested in accordance with ASTM C579
   4. Grout shall be capable of maintaining at least a flowable consistency for minimum of 30 minutes at 70 degrees F.
   5. Shear bond strength to portland cement concrete shall be greater than shear strength of concrete when tested in accordance with ASTM C882/C882M.

2.03 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Adhesive for setting dowels in concrete shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report. Adhesive shall be as per the General Structural Notes.

B. Adhesive for setting dowels in concrete masonry shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report or IAPMO Report. Adhesive shall be as per the General Structural Notes.

2.04 CONCRETE REPAIR MORTAR

A. Horizontal Applications: Repair mortars shall be:
   1. BASF, MasterEmaco S 466CI
   2. Sika Corporation, SikaTop 111 Plus
   3. Approved Equal

B. Vertical and Overhead Applications: Repair mortars shall be:
   1. BASF, MasterEmaco 1500HCR Vertical Overhead
   2. Sika Corporation, SikaTop 123 Plus
   3. Approved Equal

2.05 CEMENT GROUT

A. Cement grout shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed in accordance with this Section.
   1. Minimum Compressive Strength: 4,500 psi at 28 days.
   2. Maximum Water Cement Ratio: 0.42 by weight.
   3. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
   4. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
   5. Air Content: Five percent (plus or minus one percent).
   6. Minimum Cement Content: 564 pounds per cubic yard.
   7. Slump for grout fill shall be adjusted to match placing and finishing conditions, and shall not exceed four inches.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

3.02 CEMENTITIOUS NON-SHRINK GROUT

A. Non-shrink, cementitious, nonmetallic aggregate grout shall be used for column base plates, structural bearing plates, and all locations where the general term “non-shrink grout” is indicated on the Drawings. Use of this grout to support the bearing surfaces of machinery shall be as specified in Section 43 05 13 or as detailed on the Drawings for specific locations or pieces of equipment. If guidance is not provided in locations noted above, use of non-shrink grout for equipment mounting shall be limited to equipment less than 25 horsepower or 750 pounds. Grout shall be placed and cured in accordance with the manufacturer's instructions.

B. Non-shrink cementitious grout shall not be used as a surface patch or topping. Non-shrink cementitious grout must be used in confined applications only.

3.03 EPOXY GROUT FOR EQUIPMENT MOUNTING

A. Prepare concrete surfaces of equipment pads as indicated in details on the Drawings and as required by the epoxy grout manufacturer. Epoxy grout for equipment mounting shall be placed and cured in accordance with the requirements of Section 43 05 13, details on the Drawings, and in conformance with manufacturer’s recommendations.

3.04 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Follow manufacturer’s instructions.

3.05 CONCRETE REPAIR MORTAR

A. Concrete repair materials and procedures shall be submitted for review to the Owner's Representative and shall be accepted prior to commencement of the repair work.

B. Follow all manufacturer's instructions, including those for minimum and maximum application thickness, surface preparation and curing. Add aggregate as required per manufacturer's recommendations. Any deviations from the manufacturer's instructions shall be submitted for review to the Owner's Representative and shall be accepted prior to commencement of the work.

3.06 CEMENT GROUT

A. Cement grout shall be used for grout toppings less than four inches thick and for patching of fresh concrete.

B. Grouting shall comply with temperature and weather limitations in Section 03 30 00, Cast-In-Place Concrete.

C. Cure grout in accordance with grout manufacturer's instructions for prepackaged grout and Section 03 30 00, Cast-In-Place Concrete, for non-prepackaged cement grout.

END OF SECTION

SECTION 03 70 00

MASS CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Requirements for cast-in-place mass concrete as defined in Section 03 30 00 for Class A concrete.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 207.1R	Guide to Mass Concrete
ACI 207.2R	Report on Thermal and Volume Change Effects on Cracking Of Mass Concrete
ACI 207.4R	Cooling and Insulating Systems for Mass Concrete
ACI 301	Specifications for Structural Concrete
ASTM C494	Chemical Admixtures for Concrete

1.04 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

4. Temperature control plan, including system for monitoring the temperature of concrete and reducing excessive temperature and temperature differentials. Temperature control plan shall include the following items:
    a. Calculated or measured temperature rise of concrete.
    b. Upper limit for concrete temperature at time of placement.
    c. Description of specific measures and equipment that will be used to ensure maximum temperature in placement will not exceed specified maximum temperature limit.
    d. Calculated maximum temperature in placement based on expected conditions at time of placement and use of proposed measures to control temperatures.
    e. Description of specific measures and equipment that will be used to ensure temperature difference will not exceed specified temperature difference limit.
    f. Calculated maximum temperature difference in placement based on expected conditions at time of placement and use of proposed measures to control temperature differences.
    g. Description of equipment and procedures that will be used to monitor and log temperatures and temperature differences.
    h. Drawing showing locations for temperature sensors.
    i. Description of format and frequency of providing temperature data.
    j. Description of measures to address and reduce excessive temperatures and temperature differences, if they occur.
    k. Description of curing procedures, including materials and methods, and curing duration.
    l. Description of formwork removal procedures to ensure temperature difference at temporarily exposed surface will not exceed temperature difference limit, and how curing will be maintained.
    m. If concrete design mixture is changed, temperature control plan must be updated.
    n. Temperature control plan shall take into account and be coordinated with the lift heights that the Contractor plans for mass concrete pours. Locations of horizontal joints in the mass concrete pours due to planned lift heights shall be submitted for approval to the Engineer.
5. Performance-Based Temperature Difference Limit Approach:
    a. If the performance-based approach to differential temperatures is utilized (see Temperature Control article below in Part 3), submit report with substantiating test data and graphs showing relation between differential temperature and strength of concrete.
6. Layout of cooling pipe system, if used, showing pipe sizes and material type, connections, location, spacing, method of support, and system for monitoring the temperature of the water in the cooling pipes.

1.05 QUALITY ASSURANCE

A. General
1. Quality control shall be in accordance with Section 03 30 00, plus the additional provisions specified in this section for mass concrete.

PART 2 PRODUCTS

2.01 GENERAL

A. Mass concrete materials and concrete characteristics, including mix design, shall be in accordance with the requirements for Concrete Class in Section 03 30 00 and shall further comply with the additional requirements specified in this section.

1. Compressive Strength: Minimum compressive strength as specified in the General Structural Notes, but use 56-day compressive strength.
2. Cement:
    a. Cement shall be Portland Cement Type II (moderate heat of hydration), except as modified herein.
    b. Cement shall contain no more than 8 percent tricalcium aluminate.
    c. The sum of tricalcium aluminate and tricalcium silicate shall be less than 58 percent.
    d. Cement shall be stored in a covered, shaded silo to prevent heating by direct sunlight.
3. Coarse Aggregate:
    a. Aggregates shall be stored in a covered area and the aggregates shaded to prevent heating by direct sunlight.
    b. Aggregates shall be continuously sprayed with water to cool the aggregates. The water content of the concrete mix shall be adjusted to account for the cooling water.
4. Fine Aggregate:
    a. Aggregates shall be stored in a covered area and the aggregates shaded to prevent heating by direct sunlight.
    b. Aggregates shall be continuously sprayed with water to cool the aggregates. The water content of the concrete mix shall be adjusted to account for the cooling water.
5. Concrete Admixtures:
    a. Provide water reducing admixture, as specified in Section 03 30 00, in all mass concrete.
    b. Provide pozzolan (fly ash) as specified in Section 03 30 00 in all mass concrete. Note that only Class F fly ash is allowed.
    c. Set Retarding Admixture:
        1) At the Contractor's option, a set retarding admixture can be used to control set time and minimize premature setting of concrete and formation of cold joints.
        2) Set retarding admixture shall conform to ASTM C494, Type B.
        3) Admixture dosage shall be per the manufacturer's written requirements.
6. Water and Ice:
    a. Mixing water shall be as specified in Section 03 30 00.
    b. Ice used in lieu of, or in addition to, mixing water shall be made from water conforming to Section 03 30 00.

PART 3 EXECUTION

3.01 PLACING CONCRETE

A. Concrete placement shall conform to Section 03 30 00 except as modified herein.

3.02 TEMPERATURE CONTROL

A. General:
   1. Maximum as-delivered concrete temperature shall be 70 degrees F.
   2. During placement of concrete, temperature control measures shall be in place to limit the maximum initial concrete temperature rise to 20 degrees F during placement.
   3. The maximum allowable temperature of the concrete shall be 158 degrees F.
   4. Difference in temperature between concrete interior and surface temperatures shall not exceed 35 degrees F. As an alternative to meeting the 35 degree F maximum differential temperature limit, submit for approval a "Performance-Based Temperature Difference Limit" approach where the allowable differential temperature limit varies with the in-place compressive strength of the concrete (reference ACI 207.2R for more information on this approach). The performance based approach shall be based on measurements of key thermal and physical properties of the project mass concrete mix, such as compressive strength, elastic modulus, and tensile strength, to determine relations between these parameters.
   5. Install a temperature monitoring system to measure temperatures within the interior and at the surface of the concrete.
   6. Provide a means to control the concrete temperature differential based on the temperature monitoring data.
   7. The interior of the concrete shall be allowed to cool down and stabilize for a minimum of 21 days from the time of placement.
   8. No mass concrete placement shall occur until written approval of the temperature control plan.

B. Pre-Cooling of the Concrete Mix:
   1. Pre-cooling of the concrete mix prior to placement may also be attained by the following means:
      a. Batch water shall be cooled and ice may be substituted for a portion of the batch water.
      b. Alternative means proposed and approved by the Construction Manager.

C. Cooling During Concrete Placement:
   1. Use fog sprayers to reduce the ambient air temperature. Adjust the water content of the concrete to account for added water.

D. Post-Cooling of the Concrete:
   1. Concrete shall be water cured as soon as possible following placement per the requirements of Section 03 30 00. Cold water shall not be used for curing because it will increase the differential temperature between the surface and interior.

2. The temperature of the interior and surfaces of the concrete shall be continuously monitored during the cooling period.
3. The cooling period is defined as the time required for the interior of the concrete placement to stabilize and shall be a minimum of 21 days from the time of placement.
4. Insulating blankets may be used over the pumped curing water to prevent rapid surface cooling.
5. Embedded thin-walled piping and circulating water may be used to control heat gain in the previously cast concrete. Clearly indicate in the temperature control plan if cooling piping will be embedded in the concrete. The embedded piping shall not be installed within the top 20 inches of the slab or wall. The cooling pipe system shall be operated for the duration of the cooling period.

END OF SECTION

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SECTION 03 93 20

CHEMICAL GROUT CRACK INJECTION

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. Seal leaking cracks and joints in concrete by pressure injecting chemical resin to prevent water leakage into the areas. Work includes, but not limited to, the following.
   1. Injection of chemical grout to seal leaking cracks and joints.

1.02 RELATED SECTIONS

A. Section 03 30 00 Cast-in-Place Concrete

1.03 INJECTION SUBMITTALS

A. Product Data: Provide manufacturer's information and technical data on the injection materials.

B. Samples:
   1. Injection resin materials, 1 each type.
   2. Packers.

C. Qualification Data: For installers and manufacturers.
   1. For Injection Specialist and supervisor on the project, submit a list of at least 5 similar injection projects that the Injection Specialist and supervisor on the project have completed successfully.
   2. For products required to be installed by workers approved by product manufacturers, include letters of acceptance by product manufacturers certifying that installers are approved to apply their products.

D. Quality Control Submittals:
   1. Certificates: Furnish manufacturer's certification that materials meet or exceed Specification requirements, including certified test laboratory reports as necessary for compliance with the requirements.
   2. Manufacturer's Instructions: Furnish manufacturer's literature, specifications, and application instructions.
   3. Procedure: Submit written description of water-proofing procedures and operations sequencing based on manufacturer's requirements prior to commencing the Work.
   4. Submit intent to guarantee document (sample warranty) and all warranty requirements, with a performance guarantee against water penetration through approximately 95 percent of the length of the crack that was injected for a 1 year period. It is expected that approximately 5 percent of the injected crack area could experience leakage in the future.

E. Guarantee: Submit applicators guarantee and manufacturer’s warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: The manufacturer shall be a domestic company with at least twenty years of manufacturing experience in the field of injection resins. The manufacturer shall maintain product liability insurance in the amount at least two million dollars aggregate coverage.

B. Contractor Qualifications: Company specializing in the injection repair of cracks shall have a minimum of three years' experience and at least five similar installations of equal magnitude which have proven successful in all respects for a period of at least three years. Contractor shall be trained by the injection material manufacturer and certified in order to obtain the manufacturer's warranty.

C. Manufacturer's Representative: All work of this Section shall be performed under the supervision of the injection material manufacturer's representative. The representative shall attend pre-construction meetings and make regular visits during the course of construction to ensure that method of installation is acceptable so that warranty will be obtained.

D. Mockups: Prepare mockups for crack injection to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver all materials in the manufacturer's sealed original container's bearing the manufacturer's name and product identification in a manner to prevent damage by breakage, water or moisture.

B. Store and handle all products of this section in a strict compliance with the manufacturer's instructions.

1.06 PROJECT CONDITIONS

A. Do not execute the Work of this section unless the Owner's Representative is present, or unless the Representative directs that the Work be performed during the Representative's absence.

B. Execute the work of the section in presence of the product manufacturer's representative.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not apply if the temperature is below 50°F or above 85°F unless the material manufacturer is consulted for recommendations.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Warranty: Furnish a labor and material warranty (ies) for the Work of this Section, to cover the repair for a period of 1-year warranty. The warranty shall include but not be limited to, repair of leakage in more than 5 percent of the total length of cracks injected that were caused by defects in materials or workmanship within areas of injection. The monetary value of the warranty shall be at least equal to the original cost of the installation.

B. Should any defects develop or any leaks occur in the Work within the guarantee/warranty period, such defects or leaks shall at once be remedied and made good without cost or expense to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS, GENERAL

A. Source Limitations: Obtain each color, grade, finish, type, and variety of product from single source with resources to provide products of consistent quality in appearance and physical properties.

2.02 MANUFACTURERS

A. DeNeef Construction Chemicals Inc.

B. 5610 Brystone Drive

C. Houston, TX 77041

D. Phone: (800) 732-0166

E. Approved Equivalent.

2.03 MATERIAL

A. General:
   1. Chemical grouts (resins) are to be used for sealing concrete cracks and joints to prevent current or future water seepage. The selection of a particular material for use at a specific location shall be based on the nature of the crack or joints in relation to the materials properties.
   2. The methacrylic acrylate copolymer resin is intended for use in filling small to moderate sized cracks in concrete with little or minimal running water.
   3. The Owner shall have final approval on the choice of resin system for each application.

B. Products:
   1. Methacrylic acrylate copolymer resin:
      a. Hydrophilic methacrylic acrylate copolymer resin shall be a two component resin system for injection into cracks to create a waterproof barrier. The cured resin shall be capable of an elongation at break of 300%. Viscosity shall be less than 6-8 cps when mixed.
         1) Material shall be Superflex AR by DeNeef.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine all adjoining work on which this Work is in anyway dependent for proper installation and workmanship. Report to the Owner and Engineer any conditions that prevent the performance of this Work.

3.02 SURFACE PREPARATION AND PROTECTION

A. Remove paint, oil, and foreign material off all concrete surfaces of area to be injected prior to injection. Cleaning shall be to a degree acceptable to the injection material manufacturer.

B. Protect adjacent areas from chemicals.

C. Keep area dry by mopping and pumping in order to place material and determine crack location.

D. Clean surface of injection area to locate crack.

E. Preparatory Work:
   1. Drill holes diagonally at a 45° angle to intersect crack or joint. Hole diameter shall suit injection packer size. Injection packer shall be acceptable to the grout manufacturer.
   2. Distance from starting of hole to crack or joint shall be equal to one-half the thickness of the structural slab or wall. This will be usually determined by trial and error.
   3. If the repair is at a crack, holes should be spaced on both sides to ensure that at least one-half of the total number of holes shall intersect the crack.
   4. Spacing of holes shall be dependent upon crack width and chemical grout material viscosity to ensure continuity of seal within the crack or joint. Spacing of holes should not exceed 1'-6" on center, unless demonstrated to be effective.
   5. The drilled holes shall be produced by a rotary percussion hammer drill using a masonry bit with a minimum diameter of ½" to a maximum diameter of 5/8". Masonry bits need to be sharp and straight as not to produce out-of-round holes.
   6. The drilling of the grout holes shall in no way cause damage to the reinforcing bars or electrical conduit. It is the contractor's responsibility to locate reinforcing bars and conduit prior to drilling grout holes.

3.03 INJECTION WORK

A. Prepare components as per manufacturer's instructions. Add accelerator to suit field conditions, including, but not limited to, water flow, surface being injected, ambient temperature, crack or joint width, etc. Process chemical resin materials using appropriate protective gear including gloves, mask or goggles, and appropriate clothing. Follow manufacturer's recommendation for product safety guidelines.

B. Drill holes and cracks shall be vacuumed and cleaned with water prior to receiving packers and injection of the resin. Typical pressure needed to flush a crack shall be between 200 and 300 psi. The flushing may reveal blind drill holes, voids, cavities, honeycombs that require special treatment. Modify application procedure as required. After flushing is completed at one injector, the Contractor shall repeat the procedure at the next injector until all have been flushed.

C. Using suitable power stainless steel pumping equipment acceptable to the manufacturer, pump components through a suitable static mixer to ensure homogeneous blending of the components. Static mixer shall be firmly coupled to injection packer to make sure residue does not clog.
   1. During pumping operations take proper precautions against loose or spalled concrete dislodging and falling.

D. If injection packers have been left out of holes to verify material travels, once material is observed at the next hole, a packer shall be securely placed in that hole. Begin pumping at that next packer. If all packers have been installed prior to pumping, when material flow has been observed exiting crack or joint adjacent to another packer, begin pumping at that packer.

E. For cracks on a wall, start at the lowest port and work up injecting resin until grout material appears at the next port adjacent to the one being filled.

F. When material appears at the adjacent port, discontinue injection at entry port and begin injection at the adjacent port.

G. If water is actively flowing, use the single-component polyurethane to prevent water from flowing. After the water is stopped, re-inject the same crack with the methacrylic acrylate copolymer resin or as recommended by the manufacturer. Other cracks and joints shall be repaired by using either the methacrylic acrylate copolymer resin at the crack or joint or the acrylate monomer resin to create a barrier.

H. Should set time need to be hastened, accelerator may be added in accordance with manufacturer's recommendation and Injection Contractor's experience.

I. When work is either complete or temporarily halted, flush static mixer with manufacturer's recommended solvent to prevent clogging.

J. Injection pressures shall be kept as low as possible to allow material to thoroughly permeate the full depth of the crack or joint.

K. Injection pressure will vary from 200 psi to 3000 psi depending on the width of the crack, thickness of the structure, and condition of the concrete. Surface surrounding the cracks should be wet down with water to reduce the grout's bonding ability, thus aiding in clean-up.

L. Inject all packers until no further chemical resin can be pumped.

M. If the Injection Contractor suspects that a void exists behind and/or beneath the concrete substrate after pumping excessive amounts of mixed injection resin into an injection port, he/she should cease pumping activities and immediately notify the Engineer and Owner's Representative.
   1. This contact and notification must take place within 24 hours of the work stoppage.

2. A jobsite meeting should be organized to include all parties involved, i.e., General Contractor, injection sub-contractor, Owner's Representative, Engineer of Record, and manufacturer's representative.
3. During this meeting, the area in question should be identified and investigated. A detailed plan will be discussed and formulated to ascertain what steps may be necessary to remediate the problem. Remedial work may require the void space to be filled with a cement grout by injection to fill the void prior to injecting the area further. It may be decided to continue with the resin injection. The Contractor may require additional compensation for the unforeseen work in the area requiring the remedial cement grout injection work or the additional chemical grout material.

N. If the crack or joint continues to leak, drill hole(s) in accordance with above procedures at the leaking segment(s) and repeat procedures for injection.

O. Remove the ports after work in complete. Remove at least 1" of resin material from the top 1" of the hole of resin material, and fill hole with urethane sealant, matching the texture of the existing concrete surface.

3.04 CLEANING AND PROTECTION

A. Clean all adjacent areas of excess material; powder, resin, and droppings.

3.05 FIELD QUALITY CONTROL

A. The Engineer will observe surfaces and reject any that contain defects. Any defective areas shall be fixed at Contractor's expense.

B. All work is to be done under the supervision of the manufacturer's representative.

C. Testing Agency: Owner will engage a qualified testing agency to sample materials and perform tests as follows:
1. Crack Injection Resin: Core drilled samples to verify proper installation.
   a. Testing Frequency: 1 sample for each 300 feet (30 m) of crack injected.
   b. Where samples are taken, fill holes with epoxy mortar.

END OF SECTION

SECTION 04 20 00

UNIT MASONRY

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies masonry work consisting of concrete masonry units, general unreinforced and reinforced masonry construction.

B. Type:
   1. Masonry work shall be constructed from units of concrete or clay in combination with reinforcing, mortar, and grout as specified.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A82	Steel Wire, Plain, for Concrete Reinforcement
ASTM A90	Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM C27	Classification of Fireclay and High-Alumina Refractory Brick
ASTM C55	Concrete Building Brick
ASTM C67	Sampling and Testing Brick and Structural Clay Tile
ASTM C90	Loadbearing Concrete Masonry Units
ASTM C91	Masonry Cement
ASTM C129	Non-Load-Bearing Concrete Masonry Units
ASTM C144	Aggregate for Masonry Mortar
ASTM C150	Portland Cement
ASTM C207	Hydrated Lime for Masonry Purposes
ASTM C270	Mortar for Unit Masonry

Reference	Title
ASTM C404	Aggregates for Masonry Grout
ASTM C476	Grout for Masonry
ASTM C666	Resistance of Concrete to Rapid Freezing and Thawing
ASTM E514	Water Penetration and Leakage Through Masonry

B. Sample Panel:
   1. A sample masonry panel for each type of masonry, approximately 6 feet long by 4 feet high shall be constructed on site for approval by the Construction Manager. Each panel shall show the workmanship, coursing, bond, anchors, joint reinforcing wall ties, tooling of joints, range of color, texture of masonry, and mortar color. Finished work shall match the approved sample panel.

C. Appearance:
   1. Source or supply of materials shall not be changed after the work has started if the appearance of the finished work would be affected.

D. Efflorescence Testing:
   1. Certified efflorescence test reports shall be provided on masonry units that are to be exposed to weathering. Schedule tests far enough in advance of starting masonry work to permit retesting if necessary. Test three pairs of specimens of each type of masonry unit for efflorescence in accordance with ASTM C67. If any pair is rated "effloresced," the units represented by the samples will be rejected.

E. PRISM TESTS

F. The following information shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Shop drawings showing details of bond beams and lintels.
   3. Three representative full-size sample masonry units showing full range of color, texture, finish, and dimensions.

1.03 DELIVERY, STORAGE, AND HANDLING:

A. Cementitious materials shall be delivered to the site in unbroken containers, plainly marked and labeled with manufacturers' names and brands, stored in dry, weathertight enclosures to prevent entry of foreign materials and damage by water or dampness. Masonry units shall be stored off the ground and handled with care to avoid chipping and breakage. Materials shall be protected from damage and, except for sand, kept dry until used. Sand shall be covered to prevent intrusion of water and foreign materials and to prevent drying. Materials containing frost or ice shall not be used.

PART 2 PRODUCTS

2.01 MASONRY UNITS

A. Concrete Masonry Units:
   1. General:
      a. Concrete masonry units shall be of modular dimensions and air, water, or steam cured. Unless otherwise specified, exposed surfaces of units shall be comparatively smooth and of uniform texture. Special surface texture or, architectural faces shall be provided where specified. Surfaces of units which are to be plastered or stuccoed shall be sufficiently rough to provide a suitable bond.
   2. Hollow Load-Bearing Units:
      a. Hollow load-bearing units shall conform to ASTM C90, Grade N, Type I, made with lightweight or normal weight aggregate. Load-bearing units shall be provided, unless otherwise specified.
   3. Hollow Non-Load-Bearing Units:
      a. Hollow non-load-bearing units, where specified, shall conform to ASTM C129, Type I, made with lightweight or normal weight aggregate. Load-bearing units may be provided in lieu of non-load-bearing units.
   4. Concrete Building Brick:
      a. Concrete building brick shall conform to ASTM C55, Grade N, Type I, and shall be made with lightweight or normal weight aggregate. Concrete brick shall match the concrete masonry units in color and surface characteristics.
   5. Solid Load-Bearing Units:
      a. Solid load-bearing units shall conform to ASTM C145, Grade N, Type I, and made with lightweight or normal weight aggregates. Solid load-bearing units shall be provided where specified.
   6. Special Shapes:
      a. Special shapes such as closures, header units, and jamb units shall be provided as necessary to complete the work. Special shapes shall conform to the requirements for the units with which they are used.

B. Facing Brick:
   1. Unless building brick is specified, facing brick shall be provided for all brickwork. Facing brick shall conform to ASTM C216, Grade SW, Type Emperor, 4 inches thick, 4 inches high, and 16 inches long. Facing brick shall be of uniform Ochre Buff color with a mate texture.

C. Hollow Brick Units:
   1. General:
      a. Hollow brick units shall be of modular dimensions unless otherwise specified, exposed surfaces of units shall be comparatively smooth and of uniform texture. Where the finish surface will be visible, masonry units shall be colored based on submitted color samples chosen by the Architect.
         1) For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
         2) Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.
   2. Hollow Load-Bearing Units:
      a. Hollow load-bearing units shall conform to ASTM C652, Grade SW, Type SBX. Load-bearing units shall be provided, unless otherwise specified.
         1) Basis-of-Design Product: Interstate Brick, Atlas Brick.
         2) Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 9000 psi.
         3) Efflorescence: Provide brick that has been tested in accordance with ASTM C67/C67M and is rated "not effloresced."
         4) Size (Actual Dimensions): 7-5/8 inches wide by 3-5/8 inches high by 15-5/8 inches long.

2.02 MORTAR

A. Cement:
   1. Cement shall be Portland cement conforming to ASTM C150, Type II, low alkali containing less than 0.60 percent alkalis.

B. Hydrated Lime:
   1. Hydrated lime shall conform to ASTM C207, Type S.

C. Masonry Cement:
   1. Masonry cement shall conform to ASTM C91, except that for masonry cement used in mortar for exterior walls, the air content of the mortar specimen shall be not more than 16 percent by volume in lieu of 22 percent. Containers shall bear complete instructions for proportioning and mixing to obtain the required types of mortar.

D. Sand:
   1. Aggregate for mortar shall be sand conforming to ASTM C144.

E. Water:
   1. Water shall be clean, potable, and free from substances which could adversely affect the mortar.

F. Waterproofing Compound:
   1. Mortar shall contain an admixture of Master Builders Rheomix 235, Sonneborn Hydrocide Powder, or approved equal.

G. Mortar Types:
   1. Unless otherwise specified, mortar shall be ASTM C270, Type S. Waterproofing compound shall be added in accordance with manufacturer's recommendations. Air content shall not be less than 11 percent. Where colored mortar is specified to match the masonry units, add colorant to obtain the color indicated. Coordinate color and type with 04 26 13 Masonry Veneer mortar.

H. Premixed Mortar:
   1. Premixed mortar shall be ASTM C270, Type S for use as specified in paragraph 2.02 Mortar Types. Water proofing compound shall be added in accordance with manufacturer's recommendation. Air content shall not be less than 11 percent. Coordinate color and type with 04 26 13 Masonry Veneer mortar.

I. Admixtures:
   1. Admixtures may be used in mortar to retard curing and provide up to 36 hours of workability, provided that the admixture does not adversely affect bonding or compressive strength.

2.03 ACCESSORIES

A. Horizontal Joint Reinforcement (where required in the Drawings):
   1. Horizontal joint reinforcement shall be fabricated from cold drawn steel wire, ASTM A82. Wire shall be hot-dipped galvanized after fabrication in accordance with ASTM A153. Reinforcement shall be truss type with two or more longitudinal wires welded to a continuous diagonal cross wire, or ladder type with perpendicular cross wires not more than 16 inches o.c. Reinforcement shall be provided in flat sections 10 feet long, and preformed corners and tees approximately 30 inches long. Overall width shall be approximately 2-inches less than nominal thickness of wall.
   2. For single-wythe walls and partitions, two 9-gage longitudinal wires and 9-gage cross wires shall be provided.

B. Reinforcing Bars:
   1. Reinforcing steel shall be as specified in Section 03 20 00.

C. Anchors And Ties:
   1. General:
      a. Anchors and ties shall be approved designs of stainless steel, zinc-coated steel, or noncorrosive metal having the equivalent total strength of steel types. Zinc-coated steel shall be coated by the hot-dip process after fabrication to a minimum of 1.25 ounces of zinc per square foot of surface when tested in accordance with ASTM A90. See General Structural Notes in the Drawings for Anchors and Ties for brick veneer.
   2. Corrugated Metal Ties:
      a. Metal ties shall be not less than 7/8-inch wide by approximately 7 inches long and not lighter than 22 gage.
   3. Rigid Steel Anchors:
      a. Rigid steel anchors shall be not less than 1 inch wide, 1/4 inch thick, and 24 inches long with each end bent not less than 2 inches.

4. Dovetail Flat Bar Or Wire Anchors:
    a. Flat bar anchors shall be sheet steel, not lighter than 16 gage, and 7/8-inch wide, with end turned up 1/4 inch. Wire anchors shall be not lighter than 6 gage, 7/8-inch wide with wire looped and closed.
5. Dovetail Anchor Slots:
    a. Unless otherwise specified, Dovetail slots shall be made of galvanized steel with minimum dimensions of 1 inch wide back by 1 inch deep by 5/8-inch throat.

D. Through-Wall Flashing:
1. Flashing, where specified, shall be 5-ounce, electrolytic copper sheet, uniformly coated on both sides with acidproof, alkaliproof, elastic bituminous compound. Factory applied coating shall weigh not less than 6 ounces per square foot (approximately 3 ounces per square foot on each side).

2.04 GROUT

A. General:
1. Grout shall comply with ASTM C476, shall use Type II cement, and shall be proportioned by volume to achieve a minimum 28-day compressive strength of 2,000 psi. Grout shall have sufficient water added to produce a consistency for pouring without segregation.

B. Aggregate:
1. Aggregate shall comply with ASTM C404.

C. Fine Grout:
1. Fine grout shall be composed of one part cement, not more than 1/10 part lime, and 2 1/4 to 3 parts fine aggregate.

D. Coarse Grout:
1. Coarse grout shall be composed of one part cement, not more than 1/10 part lime, 2 to 3 parts fine aggregate, and not more than 2 parts coarse aggregate.

E. Prism test results specified in paragraph 1.02 Prism Tests."

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00. Information shall be received by the Construction Manager at least 14 days prior to the beginning of masonry work.
1. Masonry unit certificates showing compliance to the specifications shall be submitted for each type of masonry unit.
2. Reinforcing certificates showing compliance to the specifications shall be submitted for reinforcing steel, including reinforcing steel wire and joint reinforcing, as specified herein and in Section 03 20 00.
3. Certified efflorescence test reports specified in paragraph 1.02 Efflorescence Testing.
4. Shop drawings showing details of anchors, adjustable wall ties, positioning devices, and other accessories.

5. Manufacturer's data and descriptive literature for each type of masonry accessory, premixed mortar, masonry cement, grout admixtures, and flashing. Clearly mark the data to indicate which type, size, or item the Contractor intends to provide. Data shall show conformance to specified requirements and Contractor's proposed usage details.
6. Prism test results specified in paragraph 1.02 Prism Tests.

PART 3 EXECUTION

3.01 PREPARATION

A. General:
   1. Foundations for masonry work shall be straight, on-line, and level. All surfaces to be bonded with masonry shall be clean and free from laitance or foreign materials. Reinforcing dowels shall be in the correct location as specified. The placement and location of anchor ties, inserts, and other embedded items in concrete or other adjoining work shall be coordinated by the Contractor to suit the masonry work.

B. Protection:
   1. Exposed surfaces shall be protected from mortar and other stains. When mortar joints are tooled, remove mortar from exposed surfaces with fiber brushes and wooden paddles. Base of walls shall be protected from splash stains by covering adjacent ground with sand, sawdust, or polyethylene.
   2. Uniform loads shall not be applied for at least 12 hours or concentrated loads for at least 72 hours after masonry is constructed.
   3. Temporary bracing shall be provided as required to prevent damage during construction.
   4. Protective boards for polyester film shall be provided during job installation to ensure no damage from building debris.

3.02 WORKMANSHIP

A. Masonry shall be level and plumb. Story poles or gage rods shall be used throughout the work. Changes in coursing or bonding after the work is started will not be permitted; neither will carrying one section of the walls up in advance of the others be permitted. Unfinished work shall be stepped back for joining with new work; toothing will not be permitted. Heights of masonry at each floor and at sills and heads of openings shall be checked with an instrument to maintain the level of the walls. Door and window frames, louvered openings, anchors, pipes, ducts, and conduits shall be built in as the masonry work progresses. Spaces around metal door frames shall be filled solidly with mortar. Drilling, cutting, fitting, and patching to accommodate the work of others shall be performed by masonry mechanics. Masonry shall be cut with masonry saws for exposed work. Structural steelwork, bolts, anchors, inserts, plugs, ties, lintels, and miscellaneous metalwork shall be placed in position as the work progresses. Chases of approved dimensions for pipes and other purposes shall be provided where specified and necessary. Tops of exposed walls and partitions not being worked on shall be covered with a waterproof membrane secured in place and extended down at least 2 feet on both sides.

3.03 MORTAR MIXING

A. Mortar materials shall be measured in 1 cubic foot containers to maintain control and accuracy of proportions; measuring materials with shovels is not permitted. Mortar shall be mixed in a mechanical batch mixer for not less than 3 nor more than 5 minutes after all ingredients are in so as to produce a uniform mixture. Water shall be added gradually as required to produce a workable consistency. Mortar not formulated to include retarding admixtures, which has not been placed in final position within 2-1/2 hours after the initial mixing, shall not be retempered and used. Use of antifreeze compounds, salts, or other substances to lower the freezing point of mortar is prohibited.

B. Mortar shall be mixed in accordance with ASTM C270 to obtain type mortar required. Where colored mortars are required, pigments may be added at the site or provided as part of prepackaged mortar mix. When masonry cement is used, mixing shall conform to printed instructions of the masonry cement manufacturer.

3.04 MORTAR JOINTS

A. Mortar joints shall be a uniform thickness of 3/8-inch unless otherwise specified. Exposed joints shall be tooled slightly concave with a round or other suitable jointer when the mortar is thumbprint hard except where otherwise required to match existing construction. For horizontal joints, jointers shall be at least 12 inches long for brickwork and 16 inches long for concrete masonry. Jointers shall be slightly larger than the width of the joint so that complete contact is made along the edges of the units, compressing and sealing the surface of the joint. Joints that will not be exposed shall be struck flush. Vertical joints shall be tooled first. Horizontal joints shall be level; vertical joints shall be plumb and in alignment from top to bottom of wall within a tolerance of plus or minus 1/2 inch in 40 feet.

B. Weep holes shall be placed at a maximum spacing of 48 inches at the base of cavity walls or veneer walls and in the course bearing on through-wall flashing.

3.05 TOLERANCES

A. Masonry work shall be within the following limits:
   1. Pilasters and Columns: 1/4 inch from true line.
   2. Face of Brick: 1/32 inch from face of adjacent brick.
   3. Face of Concrete Masonry Unit: 1/16 inch from face of adjacent unit.
   4. Variation from True Plane: 1/4 inch in 10 feet and 1/2 inch maximum in 20 feet or more.
   5. Variation from Plumb: 1/4 inch in each story, noncumulative and 1/2 inch maximum in two stories or more.
   6. Variation from Level: 1/8 inch in 3 feet, 1/4 inch in 10 feet, and 1/2 inch maximum.
   7. Variation in Wall Thickness: Plus or minus 1/4 inch.

3.06 BRICKWORK

A. General:
   1. Brickwork shall conform to requirements of paragraph 3.05. Brick shall be selected and placed so that the better face of stretchers and headers are exposed.

B. Testing:
   1. Except during cold weather, as defined under paragraph 3.16, clay or shale brick shall be tested daily on the job, prior to laying. Testing shall be done using a wax pencil to draw a circle the size of a quarter on five randomly selected bricks and applying 20 drops of water with a medicine dropper to the surface within the circle on each brick. If the average time that the water is completely absorbed in the five bricks is less than 1 1/2 minutes, bricks represented by the five bricks tested shall be wetted. Each brick shall be nearly saturated, but surface dry when laid. During cold weather, masonry units shall be kept dry until laid.

C. Application:
   1. Unless otherwise specified, brick shall be laid in running bond. Joints between bricks shall be filled completely with mortar. The practice of slushing head joints will not be permitted. Closure bricks shall be laid with mortar on all bedding surfaces of unit to be laid and units in place. Dry or butt joints will not be permitted. Grouting shall be provided where specified. Grout all cells with reinforcing steel solid.

3.07 CONCRETE MASONRY UNIT WORK

A. General:
   1. The first course shall be laid in a full bed of mortar for the full width of the unit. Succeeding courses shall be laid in running bond unless otherwise specified. Bed-joints shall be formed by applying the mortar to the entire top surfaces of the inner and outer face shells and to head joints by applying the mortar for a width of about 1 inch to the ends of the adjoining units. The mortar shall be of such thickness that it will be forced out of the joints as the units are placed in position. Where anchors, bolts, and ties occur within the cells of the units, metal lath shall be placed in the joint at the bottom of such cells and the cells filled with mortar or grout as the work progresses. Except at grouted or reinforced masonry, concrete brick shall be used for bonding walls, working out the coursing, topping out walls under sloping slabs, distributing concentrated loads, backing brick headers, and elsewhere as required. Concrete masonry units shall not be dampened before or during laying.

B. Special Concrete Masonry Unit Work:
   1. Where exposed concrete masonry unit walls and partitions are specified, special concrete masonry unit work shall be provided. Units shall be selected for uniformity of size, texture, true plane, and undamaged edges and ends of exposed surfaces. Units shall be placed plumb, parallel, and with properly tooled joints of maximum 3/8-inch thickness, and exposed surfaces kept clean and free from blemishes or defects.

C. Reinforced Concrete Masonry Unit Walls:

1. Where vertical reinforcement occurs, cores shall be filled solid with grout, and units laid in such a manner as to preserve the unobstructed vertical continuity of cores to be filled. Adjacent webs shall be embedded in mortar to prevent leakage of grout, and mortar fins protruding from joints removed before grout is placed. Minimum clear dimensions of vertical cores shall be 2 by 3 inches. Reinforcing shall be positioned and held accurately before placing grout by tying or by using bar positioners at maximum 8-foot intervals. Vibrator shall be used to consolidate the grout. Minimum clear distance between masonry and vertical reinforcement shall be 1/2 inch. Unless otherwise specified, splices shall be formed by lapping bars not less than 40 bar diameters.

3.08 BONDING AND ANCHORING

A. Unless otherwise specified, partitions shall extend from the floor to the bottom of the construction above. Walls and partitions shall be structurally bonded and anchored to each other and to concrete walls and beams. Unless otherwise specified, non-load-bearing partitions and interior walls shall be securely anchored to the construction above in a manner that provides lateral stability while permitting unrestricted deflection of construction above. Anchors shall be completely embedded in mortar joints.

B. In addition, bonding and anchoring shall comply with the following procedures unless otherwise specified.

1. At corners of load-bearing walls, provide a true masonry bond in each course.
2. At intersections of load-bearing walls, provide a true masonry bond in each course, or anchor with rigid steel anchors not more than 2 feet apart vertically.
3. At intersections of non-load-bearing partitions with other walls or partitions, tie with wire mesh ties at vertical intervals of not more than 2 feet or with masonry bonding in alternate courses.
4. At masonry walls facing or abutting new concrete members, anchor masonry to the concrete with dovetail or wire-type anchors inserted in slots or inserts built into the concrete. To anchor masonry walls to existing concrete members, use corrugated metal ties anchored by drive pins to the concrete. Locate anchors not more than 18 inches o.c. vertically and not more than 24 inches o.c. horizontally.

3.09 HORIZONTAL JOINT REINFORCEMENT

A. Unless otherwise specified, reinforcement shall be provided at 16-inch spacing in all masonry walls. Reinforcement shall be continuous except at control joints and expansion joints. Reinforcement above and below openings shall extend not less than 24 inches beyond each side of openings. Reinforcement shall be provided in the longest available lengths, utilizing the minimum number of splices. Welded L-shaped assemblies and welded T-shaped assemblies to match the straight reinforcement shall be provided at corners and intersections of walls and partitions. Refer to the drawings for additional requirements.

3.10 CONCRETE MASONRY UNIT LINTELS AND BOND BEAMS

A. Special units, lintels, and bond beams shall have cells filled solidly with grout or concrete, and provided with not less than two No. 5 reinforcing bars, unless otherwise specified. Reinforcing shall overlap a minimum of 40 bar diameters at splices. Bond beams and reinforcing shall terminate on each side of expansion joints. Concrete masonry units used for lintels and bond beams shall have exposed surfaces of the same material and texture as the adjoining masonry units. Bond beam units shall be produced from standard vertically-voided units with precut knock-out cross walls. Lintels shall be straight and true and shall have at least 8 inches of bearing at each end. Lintels shall set at least 6 days before shoring is removed.

3.11 GROUT

A. General:

1. Fine grout shall be provided in grout spaces which are less than 2 inches in any horizontal dimension after deducting the thickness of horizontal reinforcing or in which clearance between reinforcing and masonry is less than 3/4 inch. Coarse grout shall be provided in grout spaces which are 2 inches or greater in all horizontal dimensions after deducting the thickness of horizontal reinforcing provided the clearance between reinforcing and masonry is not less than 3/4 inch. For a coarse grout pour over 6 feet high, increase grout space minimum horizontal dimension to 3 inches.

B. Placement:

1. Grout shall be placed from the interior side of walls, except as approved otherwise. Sills, ledges, offsets, and other surfaces shall be protected from grout droppings. Prior to grouting, the grout space shall be clean so that all spaces to be filled with grout do not contain mortar projections greater than 1/2 inch, mortar droppings, or other foreign material. Grout shall be well mixed to prevent segregation, shall be sufficiently fluid to flow into joints and around reinforcing without leaving voids, and shall be placed by pumping or pouring from buckets equipped with spouts. Grout shall be placed in a continuous pour in grout lifts not exceeding 6 feet. At grout pours exceeding 6 feet, cleanouts shall be provided in the bottom course at every vertical bar but shall not be spaced more than 32 inches on center for solidly grouted masonry. Pours shall be 1-1/2 inches below the top of masonry units in top course, except at the finish course. Grout shall be agitated thoroughly to eliminate voids. Masonry displaced by grouting operation shall be removed and relaid in alignment with fresh mortar.

3.12 FORMS AND SHORING

A. Contractor shall construct forms to the shape, lines, and dimensions of members indicated and make sufficiently rigid to prevent deflections which may result in cracking or other damage to supported masonry. Forms shall not be removed until members have cured.

3.13 CLEANING

A. Concrete Masonry Unit Cleaning:
   1. Contractor shall protect work which may be damaged, stained, or discolored during cleaning operations.
   2. Exposed masonry surfaces shall be cleaned with clear water and stiff fiber brushes and rinsed with clear water. Where stains, mortar, or other soil remain, scrubbing shall continue with warm water and detergent. Immediately after cleaning, each area shall be rinsed thoroughly with clear water. Damaged, stained, and discolored work shall be restored to original condition or replaced with new work.

B. Hollow Brick Unit Cleaning:
   1. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
   2. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
      a. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
      b. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Engineer approval of sample cleaning before proceeding with cleaning of masonry.
      c. 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.
      d. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
      e. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.
      f. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.
      g. Clean masonry with a proprietary acidic masonry cleaner applied according to manufacturer's written instructions.

3.14 COLD WEATHER CONDITIONS

A. Construction:
   1. During cold weather, that is, when the air temperature is below 40 degrees F and falling, or when it appears that the air temperature will drop to 40 degrees F or below within 24 hours, Contractor shall not lay masonry unless the work is protected from freezing as specified below. Surfaces receiving mortar shall be free of ice and frost. The following requirements shall be adhered to:
      a. Air Temperature 40 to 32 Degrees F:
         1) Heat sand or mixing water to produce mortar temperature between 40 and 120 degrees F.
      b. Air Temperature 32 to 25 Degrees F:
         1) Heat sand and mixing water to produce mortar temperature between 40 and 120 degrees F.

c. Air Temperature 25 to 20 Degrees F:
   1) Heat sand and mixing water to produce mortar temperature between 40 and 120 degrees F. Use other heat sources on both sides of walls under construction. Use windbreaks when wind is in excess of 15 mph.
d. Air Temperature 20 Degrees F and Below:
   1) Heat sand and mixing water to produce mortar temperature between 40 and 120 degrees F. Provide enclosures and auxiliary heat to maintain air temperature above 32 degrees F on both sides of walls under construction. Ascertain that temperatures of masonry units are not less than 20 degrees F when units are laid.

B. Protection:
1. Newly laid masonry shall be protected as specified below for the respective mean daily air temperature (MDAT), that is, the average of the daytime high temperature and the forecasted nighttime low temperature.
   a. MDAT 40 to 32 degrees F:
      1) Protect masonry from rain and snow by covering the top 4 feet with weather-resistive membrane for 24 hours after laying.
   b. MDAT 32 to 25 degrees F:
      1) Completely cover newly-laid masonry with weather-resistive membrane for 24 hours.
   c. MDAT 25 to 20 degrees F:
      1) Completely cover newly-laid masonry with insulating blankets and weather-resistive membrane for 24 hours.
   d. MDAT 20 degrees F and Below:
      1) Maintain temperature of masonry above 32 degrees F for 24 hours by providing enclosures and supplementary heat or other approved means.

3.15 SPECIAL INSPECTION

A. Special masonry inspection as defined by the Uniform Building Code will be provided by the Construction Manager where specified. The Contractor shall notify the Construction Manager of any masonry work requiring special inspection at least 48 hours before the work begins."

END OF SECTION

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SECTION 04 26 13

MASONRY VENEER

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Brick.
   2. Mortar materials.
   3. Ties and anchors.
   4. Embedded flashing.
   5. Accessories.
   6. Mortar mixes.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type and color of brick and colored mortar.

1.03 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each type and size of product.

1.04 MOCKUPS

A. Sample Panels: Build sample panels to verify selections made under Sample submittals and to demonstrate aesthetic effects. Comply with requirements in Section 01 45 00 "Contractor Quality Control" for mockups.
   1. Build sample panels for typical exterior wall in sizes approximately 48 inches long by 48 inches high by full thickness.

1.05 FIELD CONDITIONS

A. 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.

B. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602.

PART 2 PRODUCTS

2.01 UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 602, 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 will be exposed in the completed Work.

2.02 BRICK

A. General: Provide shapes indicated and as follows, with exposed surfaces matching finish and color of exposed faces of adjacent units.
   1. For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
   2. Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.

B. Clay Face Brick: Facing brick complying with ASTM C216, Grade SW, Type FBX Type FBS Type FBA.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Interstate Brick; 4" Emperor.
   2. Initial Rate of Absorption: Less than 30 g/30 sq. in. per minute when tested in accordance with ASTM C67/C67M.
   3. Efflorescence: Provide brick that has been tested in accordance with ASTM C67/C67M and is rated "not effloresced."
   4. Surface Coating: Brick with colors or textures produced by application of coatings withstand 50 cycles of freezing and thawing in accordance with ASTM C67/C67M with no observable difference in the applied finish when viewed from 10 ft..
   5. Size (Actual Dimensions): 3-5/8 inches wide by 3-9/16 inches high by 15-5/8 inches long.
   6. Color and Texture: As selected by Engineer.

2.03 MORTAR MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

B. Hydrated Lime: ASTM C207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.

D. 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.

E. Preblended Dry Mortar Mix: Packaged blend made from portland cement and hydrated lime, sand, mortar pigments, and admixtures and complying with ASTM C1714/C1714M.
   1. Preblended Dry Masonry Cement Mortar Mix:

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) Amerimix is a trademark of Bonsal American, an Oldcastle company.
   2) SPEC MIX, LLC.

F. Aggregate for Mortar: ASTM C144.
   1. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

G. Cold-Weather Admixture: Non-chloride, noncorrosive, accelerating admixture complying with ASTM C494/C494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.

H. Water: Potable.

I. Waterproofing Compound:
   1. Mortar shall contain an admixture of Master Builders Rheomix 235, Sonneborn Hydrocide Powder, or approved equal.

2.04 TIES AND ANCHORS

A. General: Ties and anchors extend at least 1-1/2 inches into veneer but with at least a 5/8-inch 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. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A1064/A1064M, with ASTM A153/A153M, Class B-2 coating.

C. Adjustable Masonry-Veneer Anchors:
   1. General: Provide anchors that allow vertical adjustment but resist a 100 lbf load in both tension and compression perpendicular to plane of wall without deforming or developing play in excess of 1/16 inch.
   2. Fabricate wire ties from 0.187-inch- diameter, hot-dip galvanized steel wire unless otherwise indicated.
   3. Masonry-Veneer Anchors; See General Structural Notes on the Drawings.

D. 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 thick.
   2. Fabricate metal drip edges from stainless steel. Extend at least 3 inches into wall and 1/2 inch out from wall, with outer edge bent down 30 degrees and hemmed.

E. Flexible Flashing:
   1. EPDM Flashing: Sheet flashing product made from ethylene-propylene-diene terpolymer, complying with ASTM D4637/D4637M, 40 mil thick.

F. 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.

G. Termination Bars for Flexible Flashing, Flanged: Stainless steel sheet 0.019 inch by 1-1/2 inches with a 3/8-inch flange at top.

2.05 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.

B. Weep/Vent Products: Use the following unless otherwise indicated:
   1. Mesh Weep/Vent: Free-draining mesh; made from polyethylene strands, full height and width of head joint and depth 1/8 inch less than depth of outer wythe; in color selected from manufacturer's standard.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Mortar Net Solutions ; Mortar Net Weep Vents. or a comparable product by one of the following:
         1) CavClear; a division of Archovations, Inc.
         2) Hohmann & Barnard, Inc.
         3) Keene Building Products.
         4) Or approved equal.

C. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.
   1. Mortar Deflector: Strips, full depth of cavity and 10 inches high, with dovetail-shaped notches that prevent clogging with mortar droppings.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Mortar Net Solutions; Mortar Net with Insect Barrier or a comparable product by one of the following:
         1) Advanced Building Products Inc.
         2) Hohmann & Barnard, Inc.
         3) Keene Building Products.
         4) Wire-Bond.
         5) York Manufacturing, Inc.
         6) Or approved equal.

D. Proprietary Acidic Masonry Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.

2.06 MORTAR 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 portland cement-lime 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. Use Type N unless another type is indicated.

D. Pigmented Mortar: Use colored cement product.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. 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.

B. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.

C. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. per minute when tested in accordance with ASTM C67/C67M. Allow units to absorb water so they are damp but not wet at time of laying.

3.02 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 or minus 1/4 inch.
   2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch.
   3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2 inch 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 ft., or 1/2-inch 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 ft., 1/4 inch in 20 ft., or 1/2-inch maximum.
3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 ft., 3/8 inch in 20 ft., or 1/2-inch 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 ft., 1/4 inch in 20 ft., or 1/2-inch maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 ft., 3/8 inch in 20 ft., or 1/2-inch maximum.

C. Joints:
1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch, with a maximum thickness limited to 1/2 inch.
2. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch. Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch.

3.03 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 horizontal face dimensions at corners or jambs.

C. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.

3.04 MORTAR BEDDING AND JOINTING

A. Lay masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

B. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

3.05 ANCHORED MASONRY VENEERS

A. Anchor masonry veneers to concrete and masonry backup with seismic masonry-veneer anchors to comply with the following requirements:
1. Embed connector sections and continuous wire in masonry joints.
2. Locate anchor sections to allow maximum vertical differential movement of ties up and down.

3. Space anchors as indicated, but not more than 16 inches o.c. vertically and horizontally. Install additional anchors within 12 inches of openings and at intervals, not exceeding 24 inches, around perimeter.

B. Provide not less than 1 inch of airspace between back of masonry veneer and face of insulation.

3.06 FLASHING, WEEP HOLES, AND VENTS

A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and 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 and shelf angles, extend flashing 6 inches minimum, to edge of next full unit at each end. At heads and sills, extend flashing 6 inches minimum, to edge of next full unit and turn ends up not less than 2 inches to form end dams.
   3. Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch back from outside face of wall, and adhere flexible flashing to top of metal drip edge.

C. Install weep holes in veneers in head joints of first course of masonry immediately above embedded flashing.
   1. Use specified weep/cavity vent products to form weep holes.
   2. Space weep holes 24 inches o.c. unless otherwise indicated.

D. Place cavity drainage material in airspace behind veneers to comply with configuration requirements for cavity drainage material in "Accessories" Article.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections. 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 will be at Contractor's expense.

B. Inspections: Special inspections in accordance with Level 2 in TMS 402.
   1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.

C. Testing Prior to Construction: One set of tests.

D. Clay Masonry Unit Test: For each type of unit provided, in accordance with ASTM C67/C67M for compressive strength.

E. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, in accordance with ASTM C780.

3.08 CLEANING

A. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

B. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
   1. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
   2. 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.
   3. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
   4. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.
   5. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.

3.09 MASONRY WASTE DISPOSAL

A. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.
   1. Do not dispose of masonry waste as fill within 18 inches of finished grade.

B. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION

SECTION 05 05 14

HOT-DIP GALVANIZING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Hot-dip galvanizing of steel materials.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 09 90 00 Painting and Coating

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A143	Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A384	Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A385	Providing High-Quality Zinc Coatings (Hot-Dip)
ASTM A780	Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B6	Zinc
ASTM D6386	Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM E536	Test Methods for Chemical Analysis of Zinc and Zinc Alloys
DOD-P-21035A	Paint, High Zinc Dust Content, Galvanizing Repair

1.04 SUBMITTALS

A. Action Submittals
   1. Procedure: Section 01 33 00:
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Coating applicator's Certificate of Compliance that the hot-dip galvanized coating meets or exceeds the specified requirements of ASTM A123 or A153, as applicable.
5. Evidence that the galvanized coating applicator is a member of the American Galvanizing Association.

1.05 QUALITY ASSURANCE

A. Hot-dip galvanized coating applicator shall be a member of the American Galvanizing Association.

PART 2 PRODUCTS

2.01 MATERIALS

A. Zinc used for galvanizing shall conform to ASTM B6, and shall be at least equal to the grade designated as Prime Western.

B. Maximum amount of aluminum added to a galvanizing bath shall not exceed 0.01 percent.

C. Hot-Dip Galvanized Coating: Conform to ASTM A123 and A153, as applicable.

D. Repair: Zinc dust-zinc oxide coating conforming to DOD-P-21035A and containing 95 percent zinc in the dry film. Acceptable product is ZRC Cold Galvanizing Compound by ZRC Worldwide, or approved equal.

2.02 FABRICATION REQUIREMENTS

A. Fabrication practices for products to be galvanized: In accordance with applicable portions of ASTM A143, A384 and A385. Avoid fabrication techniques that could cause steel distortion or embrittlement.

B. Coordinate with steel detailer to provide vent and drain holes of sufficient size and quantity to achieve specified galvanized coating.

PART 3 EXECUTION

3.01 PREPARATION

A. Casting surfaces to be galvanized shall be sand blasted or ground smooth. When a smooth cast is required, castings shall be tumbled and all high spots ground flush. Castings shall be normalized to prevent cracking. Malleable iron shall be safeguarded against embrittlement by pre-annealing.

B. Steel work shall be precleaned utilizing a caustic bath, acid pickle and flux or shall be blast cleaned and fluxed to obtain an acceptable surface for quality hot dip galvanizing.

3.02 APPLICATION

A. Steel Members, Fabrications, and Assemblies: Hot-dip galvanize after fabrication in accordance with ASTM A123.

B. Steel Bolts, Screws, Nuts, Washers and Hardware Components: Hot-dip galvanize in accordance with ASTM A153.

3.03 COATING REQUIREMENTS

A. Hot-dip Coating Thickness: Conform to ASTM A123 or ASTM A153, as applicable.

3.04 TESTING

A. Chemical analysis for impurities in the bath shall be made in conformity with ASTM E536.

B. Test Requirements and Methods: In accordance with ASTM A123 or ASTMA153, as applicable.

3.05 GALVANIZED SURFACES TO BE PAINTED

A. Where galvanized surfaces are specified to be painted in Section 09 90 00 or elsewhere in the Project Manual, conform to ASTM D6386.

3.06 REPAIR OF DEFECTIVE GALVANIZED COATING

A. Where zinc coating has been damaged after installation, clean substrate surface and repair with zinc dust-zinc oxide coating in accordance with ASTM A780. Apply zinc dust-zinc oxide coating in accordance with manufacturer's recommendation. Apply multiple coats to achieve a minimum film thickness of 8 mils.

B. Remove items not physically damaged, but which have insufficient or deteriorating zinc coatings, and items damaged in shipment or prior to installation, from the project site for repair by the hot-dip zinc coating method.

END OF SECTION

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SECTION 05 05 20

ANCHOR BOLTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bolts and all-thread rods used to attach structural elements and equipment to concrete and concrete masonry. Included are cast-in-place and post-installed anchors (adhesive systems and wedge type expansion anchors), nuts and washers.

B. Cast-in-place and post-installed anchors shall be Type 316 stainless steel unless noted otherwise.

1.01 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 03 30 00 Cast-In-Place Concrete
   3. Section 03 60 00 Grouting
   4. Section 43 05 13 Rigid Equipment Mounts
   5. Section 43 05 18 Vibration Isolation Systems

1.02 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 318	Building Code Requirements for Structural Concrete
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A563	Carbon and Alloy Steel Nuts
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
ASTM F844	Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F1554	Anchor Bolts, Steel, 36, 55, 105-ksi Yield Strength
IBC	International Building Code with local amendments

1.03 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Anchor bolt placement plans.
   5. Anchor bolt, nut, and washer material information, including material certifications.
   6. Record copy of design calculations and details showing the required diameter, length, embedment, edge distance, confinement, anchor reinforcement, anchor bolt sleeves, connection redesign, and other conditions, stamped and signed by a Professional Engineer currently registered in the state of Utah. Calculations shall comply with the provisions of ACI 318-19, Chapter 17. Base anchor capacity determination on cracked concrete condition and compressive strength of new concrete per Section 03 30 00. Assume compressive strength of existing concrete is 3,000 psi unless otherwise noted.
   7. Submit record copy of proof loading test results within five days after test.
   8. Product Data:
      a. ICC Evaluation Service Reports for post-installed adhesive type anchors and expansion (wedge type) anchors when allowed. Products shall be ICC approved for use in cracked concrete in high seismic areas (Seismic Design Category D, E and F).
      b. Product data indicating load capacity charts/calculations.
      c. Chemical resistance.
      d. Temperature limitations.
      e. Manufacturers written installation instructions.
   9. Installer certification for horizontal or upwardly inclined adhesive anchors in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program.

1.04 QUALITY ASSURANCE

A. Quality Assurance By Owner
   1. Special inspection of anchor bolts shall be performed by the Special Inspector under contract with the Owner and in accordance with IBC Chapter 17.
   2. A five percent sample of installed post-installed anchors shall be proof-loaded by an independent laboratory contracted by the Contractor. The quantity of samples and locations shall be coordinated with the Owner's Representative.

3. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
4. The Special Inspector shall furnish a report to the Engineer, Owner's Representative, and Building Official that the work covered by the report has been performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Certifications
1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined adhesive anchors.

PART 2 PRODUCTS

2.01 GENERAL

A. Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 1/4 inch. Minimum anchor bolt diameter shall be 1/2 inch. Anchor bolts for equipment mounting and vibration isolation systems shall be provided as specified in Sections 43 05 13 and 43 05 18, respectively.

B. Tapered washers shall be provided where mating surface is not square with the nut.

C. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings. Substitution of post-installed anchors will not be permitted unless specifically requested by the Contractor and approved by the Engineer.

2.02 PERFORMANCE/DESIGN CRITERIA

A. Anchor bolts for equipment shall be designed by the equipment manufacturer to include equipment operational loads combined with seismic and wind forces when applicable. Design criteria provided in Section 01 73 24.

B. Design anchor bolts for support and bracing of non-structural components and non-building structures for loading specified in Section 01 73 24.

2.03 MATERIALS

A. Anchor bolt materials shall be as specified in the following table:

Material	Specification
Stainless Steel Anchor Bolts	ASTM A193 or A320, Type 316
Stainless Steel Threaded Rods	ASTM F593, Type 316
Stainless Steel Nuts	ASTM A194 Heavy Hex Nuts, Type 316 ASTM F594 Heavy Hex Nuts at Adhesive Anchors, Type 316 ASTM A194 Heavy Hex Nuts Grade 8S (Nitronic 60)
Stainless Steel Washers	Type 316 to match bolt material
Carbon Steel Anchor Bolts	ASTM F1554, Grade 36, Hot Dip Galvanized

Material	Specification
High-Strength Carbon Steel Anchor Bolts	ASTM F1554, Grade 55, Weldable per Supplementary Requirement S1, Hot Dip Galvanized
Carbon Steel Nuts and Washers	ASTM A563 and F844, Heavy Hex, Hot-Dip Galvanized
Concrete Adhesive Anchors	Hilti “HIT-RE 500v3”, Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Adhesive Anchors	Hilti "HIT-HY 70", Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Expansion (wedge) Anchors*	Hilti "KWIK BOLT 3", or approved equal, Type 316 Stainless Steel
Concrete Expansion (wedge) Anchors *	Hilti “KWIK BOLT TZ”, or approved equal, Type 316 Stainless Steel

**Post installed anchors shall always be an adhesive type anchor system except where noted otherwise or when Contractor makes a request for a specific application and Engineer approves.*

2.04 STAINLESS STEEL FASTENER LUBRICANT (ANTI-SEIZING)

A. Anti-seizing Lubricant for Stainless Steel Threaded Connections:
   1. Suitable for potable water supply.
   2. Formulated to resist washout.
   3. Acceptable manufacturers are Bostik, Saf-T-Eze, or equal.

2.05 ANCHOR BOLT SLEEVES

A. Provide anchor bolt sleeves as shown on design drawings and as required by equipment manufacturer’s design.
   1. Provide high density polyethylene plastic sleeves of single unit construction with deformed sidewalls such that the concrete and grout lock in place.
   2. The top of the sleeve shall be self-threading to provide adjustment of the threaded anchor bolt projection.
   3. Acceptable manufacturers are Contec, Wilson, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings.

B. Grouting of anchor bolts using plastic sleeves with non-shrink or epoxy grout, where specified, shall be in accordance with Section 03 60 00.

C. The threaded end of anchor bolts and all-thread rods shall be long enough to project through the entire depth of the nut and if too long, shall be cut off at ½-inch beyond top of nut and ground smooth.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position using templates while the concrete is placed.

B. After anchor bolts have been embedded, their threads shall be protected by grease and the nuts run on.

3.03 ADHESIVE ANCHOR BOLTS

A. Note that adhesive anchors shall not be substituted for cast-in-place anchor bolts unless the adhesive anchors have been specified or shown on the Drawings, or approval has been obtained from the Engineer that substitution of adhesive anchors is acceptable for the specific use and location. Use of adhesive anchors shall be subject to the following conditions:
   1. Limit to locations where intermittent or continuous exposure to the following is extremely unlikely:
      a. Acid concentrations higher than 10 percent
      b. Chlorine gas
      c. Machine or diesel oils
   2. Limit to applications where exposure to the following is extremely unlikely:
      a. Fire
      b. Concrete or rod temperature above 120 degrees F
   3. Overhead applications (such as pipe supports) shall not be allowed unless approved by the Engineer and installation is by an Installer specially certified for overhead applications.
   4. Approval from Engineer for specific application and from supplier of equipment to be anchored, if applicable.
   5. Anchor diameter and material shall be per Contract Documents or equipment manufacturer's specifications. Anchor shall be threaded or deformed the full length of embedment and shall be free of rust, scale, grease, and oils.
   6. Embedment depth shall be as specified or as required by the equipment manufacturer.
   7. Follow the anchor system manufacturer's installation instructions.
   8. Holes shall have rough surfaces created by using a hammer drill with carbide bit. Core drilled holes are not allowed.
   9. Holes shall be blown clean with oil-free compressed air and be free of dust or standing water prior to installation. Follow additional requirements of the adhesive manufacturer.
   10. Concrete and air temperature shall be compatible with curing requirements of adhesives per adhesive manufacturer's instructions. Anchors shall not be placed in concrete when the temperature is below 25 degrees F.
   11. Anchors shall be left undisturbed and unloaded for full adhesive curing period, which is based on temperature of the concrete.

3.04 EXPANSION ANCHORS

A. Expansion (wedge type) anchors shall not be substituted for cast-in-place anchor bolts or adhesive anchors unless approved by the Engineer for a specific application. Use of expansion anchors shall be subject to conditions 4 through 9 as specified above for adhesive anchors. Expansion anchors shall not be used in a submerged condition or in mounting of equipment subject to vibration or cyclic motion.

3.05 REINFORCING STEEL CONFLICTS WITH POST-INSTALLED ANCHOR INSTALLATION

A. When reinforcing steel is encountered in the drill path, slant drill to clear obstruction and provide beveled washer to match angle of anchor. Drill shall not be slanted more than 10 degrees.

B. Where slanting the drill does not resolve the conflict, notify the Owner's Representative and resolve the conflict to the satisfaction of the Owner's Representative in consultation with the Engineer.

C. Abandoned post-installed anchor holes shall be cleaned and filled with non-shrink grout and struck off flush with adjacent surface.

D. The costs of determining and executing the resolution shall be borne by the Contractor. The determination and execution of the resolution shall not result in additional cost to the Owner.

E. Reinforcing steel in masonry shall not be damaged.

F. In order to avoid or resolve a conflict, locate embedded reinforcing steel using non-destructive methods and/or redesign the attachment.
   1. Redesign shall be done by the Contractor's Professional Engineer currently registered in the state of Utah.
   2. Calculations and details for redesign shall be submitted.

END OF SECTION

SECTION 05 10 00

STRUCTURAL METAL FRAMING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Structural metals consisting of standard shapes, hollow sections, fasteners, rods and plates that are used in structural supports and connections.

1.02 RELATED SECTIONS REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
AISC 201	AISC Certification Program for Structural Steel Fabricators
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 341	Seismic Provisions for Structural Steel Buildings
AISC 358	Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications
AISC 360	Specification for Structural Steel Buildings
AISC 810	Erection Bracing of Low-Rise Structural Steel Frames
ASTM A6	General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A36	Carbon Structural Steel
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193	Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low Temperature Service
ASTM A325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A384	Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A992	Structural Steel Shapes
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM F436	Hardened Steel Washers
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs

Reference	Title
ASTM F594	Stainless Steel Nuts
AWS-B3.0	Welding Procedures and Performance Qualifications
AWS-D1.1	Structural Welding Code–Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code - Stainless Steel
ASW D1.8	Structural Welding Code – Seismic Supplement
IBC	International Building Code
AISC Steel Construction Manual	American Institute of Steel Construction, Manual of Steel Construction

1.03 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Shop drawings for approval prior to fabrication. Shop drawings shall not be reproductions of the Drawings. Include complete information for the fabrication and erection of the structure's components, including the location, type, and size of bolts, welds, member sizes and lengths, coatings, connection details, blocks, copes, and cuts. Substitutions of details shown on the Drawings shall be clearly highlighted on the fabrication drawings. Explain the reasons for any deviations from the Drawings.
5. Certification that steel fabricator is approved to perform steel fabrication without special inspection.
6. AISC quality certification: Evidence that steel fabricator has AISC 201 Certification as a “Standard Steel Building Structures” fabricator. Certificate to show name and address of certified firm, effective date, and category of certification.
7. Welding procedures, qualifications, and inspection report.
8. Certified mill test reports for structural steel and high-strength bolts and nuts.
9. In accordance with IBC Chapter 17, Fabricator at the completion of fabrication to submit Certification of Compliance stating that the fabrication was performed in accordance with the design documents.
10. Certified copies of all surveys conducted by a registered professional engineer or surveyor showing elevations and locations of base plates and anchor bolts to receive structural steel or aluminum, and final elevations and locations for major members. Indicate discrepancies between actual installation and contract documents.

1.04 QUALITY ASSURANCE

A. Quality Control by Owner:
   1. Special Inspection of structural metals work shall be performed by the Special Inspector under contract with the Owner and in conformance with the IBC Chapter 17. Special Inspector(s) and laboratory shall be acceptable to the Owner in their sole discretion. Special Inspection of structural metals is in addition to, but not replacing, other inspections and quality control requirements herein. Where sampling and testing required herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.
   2. All structural steel work shall receive Special Inspection in accordance with IBC, Chapter 17. Structural steel includes all steel elements that resist code-defined loads and whose failure would affect life safety. Items to be inspected include, but are not limited to, mechanical/electrical supports, beams, stringers, columns, access walkways and stairways.

B. Fabricator Qualifications:
   1. A qualified fabricator must participate in the AISC 201 Certification program and be designated an AISC Certified Plant, Category STD (Standard for Steel Building Structures).

PART 2 PRODUCTSMATERIALS

A. Steel:
   1. Materials for structural metals shall be as specified in Table A.

Table A - Steel Materials

Material	Specification
Standard steel S-shapes, channels, angles and plates	ASTM A36
Standard rolled steel wide-flange sections and WTs	ASTM A992
Pipe sections for posts	ASTM A53, Type E or S, Grade B
Round Hollow Structural Sections (HSS)	ASTM A500, Grade B (Fy=42 ksi)
Square and Rectangular Hollow Structural Sections (HSS)	ASTM A500, Grade B (Fy = 46 ksi)
Stainless steel bolts (used at stainless steel and aluminum framing unless noted otherwise)	ASTM F593, Type 316
Stainless steel nuts and washers (used at stainless steel and aluminum framing unless noted otherwise)	ASTM F594, Type 316
Steel bolts (used at galvanized and painted steel framing)	Galvanized ASTM A325 (Type 1), bearing type bolts fully tensioned
Carbon steel nuts and washers	Galvanized ASTM A563 nuts and galvanized ASTM F436 washers

B. Aluminum:

Table B - Aluminum Materials

Material	Specification

Table B - Aluminum Materials

Material	Specification
Aluminum structural shapes	Alloy 6061-T6 per ASTM B308
Bolts	Use stainless steel bolts for aluminum framing (see Table A above)
Aluminum guardrail and handrail pipe	Alloy 6061-T6 or 6063-T6 per ASTM B241
Aluminum plates	Alloy 6061-T6 per ASTM B209

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept conditions before beginning work.

3.02 FABRICATION

A. Fabrication of steel shall be in accordance with the applicable provisions of the AISC Steel Construction Manual, sixteenth Edition. Fabrication of aluminum shall be in accordance with Aluminum Design Manual – Latest Edition. Fabrication and assembly shall be done in the shop to the greatest extent possible. The fabricating plant shall be certified under AISC 201 for Category STD (Standard for Steel Building Structures).

B. Compression joints depending on contact bearing shall have a surface roughness not in excess of 500 micro-inch and ends shall be square within the tolerances for milled ends specified in ASTM A6.

C. Shop splices of members will be permitted only where indicated on the Drawings. Splices not indicated require the approval of the Owner's Representative.

D. Verify measurements at the job site prior to fabrication. Fabricate to match job site measurements.

E. Provide holes as necessary or as indicated for securing other work to structural steel framing, and for passage of other work through steel framing members.

3.03 INSTALLATION

A. General:
   1. Erection of structural steel shall be in accordance with the applicable provisions of AISC Steel Construction Manual. Erection plan shall conform to AISC 303. For low-rise structural steel buildings, 60 feet tall or less and a maximum of 2 stories, the structure shall be erected in accordance with AISC 810.
   2. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in place work.
   3. Employ a registered professional engineer or surveyor for accurate erection of the structural steel. Check elevations of concrete and locations of anchor bolts before erection proceeds and report discrepancies to the Owner's Representative.
   4. Placement tolerances shall be in accordance with AISC 303.

5. After final positioning of steel members, provide full bearing under base plates and bearing plates using non-shrink grout. Place non-shrink grout in accordance with the manufacturer's instructions.
6. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings or isolators. Protect aluminum in contact with concrete or grout with a heavy coat of bituminous paint.
7. Metalwork to be embedded in concrete shall be placed accurately and held in correct position while the concrete is placed. The surfaces of metalwork in contact with or embedded in concrete shall be thoroughly cleaned.
8. Structural steel completely encased in concrete shall not be galvanized or painted and shall have a clean surface for bonding to concrete.
9. Metalwork which is bent, broken or otherwise damaged shall be repaired or replaced.

B. Welding:
1. Welding shall be done by welders, welding operators, and tackers who have been qualified by tests as prescribed by AWS to perform the type of work required. The quality of welding shall conform to AWS Codes.
2. Develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures.
3. Provide continuous seal welds for plates or structural shapes that are exposed to or submerged in water or wastewater.

C. Bolted Connections:
1. Bolted connections, unless noted otherwise, shall conform to AISC 360 and AISC 341, and shall be bearing type connections with bolts fully tensioned unless connecting HSS shapes. Punch, subpunch and ream, or drill bolt holes perpendicular to the surface of the member. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Bolts, nuts, and washers shall be clean of dirt and rust and lubricated immediately prior to installation. No drifting of bolts or enlargement of holes will be allowed to correct misalignment. Holes shall not be cut or enlarged by burning. Mismatched holes shall be corrected with new material.

3.04 CORROSION PROTECTION

A. Unless otherwise specified, carbon steel shall be galvanized. If coatings are indicated on the Drawings or elsewhere in the Specifications, coat in accordance with Section 09 90 00. Coating surface preparation shall be as specified in Section 09 90 00 and shall include the following operations:
1. Grind the exterior and interior edges of all flame-cut plates or members to a smooth surface.
2. Grind all sharp edges off of the sheared plates and punched holes.
3. Grind uneven or rough welds with high beads to a smooth finish.

3.05 CLEANING

A. After installation, damaged surfaces of shop primed metals shall be cleaned and touched up with the same material used for the shop coat. Damaged surfaces of galvanized metals shall be repaired as specified in Section 05 05 14.

END OF SECTION

SECTION 05 31 23

STEEL ROOF DECKING

PART 1 GENERAL

1.01 DESCRIPTION

A. General:
   1. This section specifies fabrication and erection of steel roof deck.

B. Related Sections:
   1. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
      a. Section 05 10 00 – Structural Metal Framing
      b. Section 05 05 14 – Hot-Dip Galvanizing

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AISI SG-673	Design of Cold-Formed Steel Structural Members
ASTM A36	Carbon Structural Steel
ASTM A611	Steel, Sheet, Carbon, Cold Rolled, Structural Quality
ASTM A653	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron, Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM 780	Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
ASTM A924	Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM D1056	Standard Specification for Flexible Cellular Materials Sponge or Expanded Rubber.
AWS D1.3	Structural Welding Code Sheet Steel
Steel Deck Institute (SDI)	Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Metal Floor Deck with Electrical Distribution
FMDS	FM Global Property Loss Prevention Data Sheets

1.03 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Complete shop drawings showing framing and deck layout indicating length, type, cross section, thickness, markings of metal deck units, and size and locations of all openings. Shop drawings shall not be a reproduction of the Contract Drawings.

C. Details and gages of all accessories and miscellaneous items showing sump pans, cant strips, ridge and valley plates, closure strips and insulation supports.

D. Manufacturer's load table including design thickness in inches, section properties, allowable gravity load, allowable diaphragm shear loads.

E. Erection marks. Mark each bundle to correspond to the shop drawings.

F. Certification from SDI that manufacturer is a member of SDI and that the steel roof deck is designed in accordance with SDI standards.

G. Certification for installers of deck fastening systems.

1.04 QUALITY ASSURANCE

A. Steel roof deck shall conform to the requirements of the SDI standard for Steel Roof Deck.

B. Deck manufacturer shall be a member of the Steel Deck Institute and design of the deck shall be by a qualified professional engineer.

C. Deck installer shall have minimum three years experience on comparable steel deck projects. Installers shall be trained and certified by manufacturer to install fastening systems.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store materials off the ground with one end elevated to provide drainage. Protect from the elements with a waterproof covering, ventilated to avoid condensation. Prevent rust, deterioration and accumulation of foreign materials.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sheet Steel:
   1. ASTM A653, SS, Grade 33, minimum yield 38 ksi, with Designation G60 galvanized coating, unless noted otherwise.

B. Structural Steel:
   1. ASTM A36, unless noted otherwise.

C. Galvanizing Repair Paint:
   1. Paint shall be 95 percent zinc dust, organic vehicle primer compatible with galvanized surfaces per Section 05 05 14.

2.02 FABRICATION

A. General:
   1. Form deck units in lengths to span three or more support spacings, with minimum two-inch laps and side laps. Configuration shall be appropriate for side lab connection.
   2. Deck profile and gage shall be as shown on the drawings. Acceptable manufacturer is Verco or approved equal.

B. Closure Plates:
   1. Fabricate closure plates of galvanized sheet steel of same quality as deck units. Provide tight-fitting closure with deck units.

C. Fabrication Tolerances:
   1. Maximum variation in unit alignment shall be 1/4 inch in 40 feet.

PART 3 EXECUTION

3.01 INSPECTION

A. Check supporting members for correct layout and alignment. Verify that surfaces to receive steel deck are free of debris. Do not proceed with installation until defects are corrected.

3.02 INSTALLATION

A. Install steel roof deck and accessories in accordance with the manufacturer's instructions and in accordance with final approved shop drawings and as specified herein.

B. Fasten steel roof deck to all interior and exterior transverse supports and at side laps and longitudinal supports. Deck fasteners and fastener spacing shall be as shown on the Drawings. End lap of steel roof deck shall be at least 2 inches and shall occur over transverse supporting members.

C. Coordinate size, location, and details of penetrations with the Drawings, other trades, and details of approved equipment. Pipe and conduit openings in the steel roof deck shall be reinforced according to the manufacturer's recommendation.
   1. Cutting and Fittings:
      a. Cut and fit steel roof deck units and accessories around projections through steel roof deck.
      b. Make cuts neat, square, and trim.
      c. Cut openings in steel roof deck true to dimensions using metal saws or drills.
      d. Do not use cutting torches.
      e. Openings less than 12-in in greatest dimension shall be reinforced as indicated in the drawings.

D. Suspended ceilings, light fixtures, ducts, piping, conduits, or other utilities shall not be attached to steel roof deck.

3.03 FIELD PAINTING

A. Touch up galvanized surfaces with galvanizing repair paint applied in accordance with manufacturer’s instructions and Section 05 05 14.

3.04 INSPECTION

A. The Engineer reserves the right to observe steel roof deck in the field for compliance with the requirements specified herein and the approved shop drawings. The Engineer may reject or require repair or re-fabrication of steel roof deck or accessories not meeting these requirements.

END OF SECTION

SECTION 05 40 00

COLD-FORMED METAL FRAMING

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. Exterior load-bearing wall framing.
   2. Joist framing.
   3. Soffit framing.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of cold-formed steel framing product and accessory.

B. Shop Drawings:
   1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
   2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Welding certificates.

C. Product Test Reports: For each listed product, for tests performed by manufacturer and witnessed by a qualified testing agency.
   1. Steel sheet.
   2. Expansion anchors.
   3. Power-actuated anchors.
   4. Mechanical fasteners.
   5. Miscellaneous structural clips and accessories.

D. Research Reports: For non-standard cold-formed steel framing, from ICC-ES.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Product Tests: Mill certificates or data from a qualified independent testing agency, or in-house testing with calibrated test equipment indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, and metallic-coating thickness.

C. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect cold-formed steel framing from corrosion, moisture staining, deformation, and other damage during delivery, storage, and handling.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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. AllSteel & Gypsum Products, Inc.
   2. California Expanded Metal Products Company.
   3. ClarkWestern Building Systems, Inc.
   4. Consolidated Fabricators Corp.; Building Products Division.
   5. Craco Mfg., Inc.
   6. Custom Stud Inc.
   7. Design Shapes in Steel.
   8. Dietrich Metal Framing; a Worthington Industries Company.
   9. Formetal Co. Inc. (The).
   10. MarinoWARE.
   11. Nuconsteel; a Nucor Company.
   12. Olmar Supply, Inc.
   13. Quail Run Building Materials, Inc.
   14. SCAFCO Corporation.
   15. Southeastern Stud & Components, Inc.
   16. State Building Products, Inc.
   17. Steel Construction Systems.

18. Steel Network, Inc. (The).
19. Steel Structural Systems.
20. Steeler, Inc.
21. Super Stud Building Products, Inc.
22. Telling Industries, LLC.
23. United Metal Products, Inc.
24. United Steel Manufacturing.

2.02 PERFORMANCE REQUIREMENTS

A. Cold-Formed Steel Framing Design Standards:
   1. Floor and Roof Systems: AISI S210.
   2. Wall Studs: AISI S211.
   3. Headers: AISI S212.

B. AISI Specifications and Standards: Unless more stringent requirements are indicated, comply with AISI S100 and AISI S200.

2.03 COLD-FORMED STEEL FRAMING, GENERAL

A. Steel Sheet: ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of grade and coating weight as follows:
   1. Grade: As indicated.
   2. Coating: G60, A60, AZ50, or GF30.

B. Steel Sheet for Drift Clips: ASTM A 653/A 653M, structural steel, zinc coated, of grade and coating as follows:
   1. Coating: G60 (Z180).

2.04 EXTERIOR LOAD-BEARING WALL FRAMING

A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: As indicated.
   2. Flange Width: 1-5/8 inches.

B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges, and as follows:
   1. Minimum Base-Metal Thickness: As indicated.
   2. Flange Width: 1-1/4 inches.

2.05 SOFFIT AND CEILING JOIST FRAMING

A. Steel Joists: Manufacturer's standard C-shaped steel joists, of web depths indicated, punched, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: As indicated.
   2. Flange Width: As indicated.

B. Steel Joist Track: Manufacturer's standard U-shaped steel joist track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: As indicated.
   2. Flange Width: 1-1/4 inches minimum.

2.06 FRAMING ACCESSORIES

A. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.

B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
   1. Supplementary framing.
   2. Bracing, bridging, and solid blocking.
   3. Web stiffeners.
   4. Anchor clips.
   5. End clips.
   6. Foundation clips.
   7. Joist hangers and end closures.
   8. Hole reinforcing plates.
   9. Backer plates.

2.07 ANCHORS, CLIPS, AND FASTENERS

A. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.

B. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
   1. Head Type: Low-profile head beneath sheathing, manufacturer's standard elsewhere.

C. Welding Electrodes: Comply with AWS standards.

2.08 MISCELLANEOUS MATERIALS

A. Galvanizing Repair Paint: SSPC-Paint 20 or MIL-P-21035B or ASTM A 780.

B. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.

C. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents, complying with ASTM C 1107/C 1107M, with fluid consistency and 30-minute working time.

D. Shims: Load bearing, high-density multimonomer plastic, and nonleaching; or of cold-formed steel of same grade and coating as framing members supported by shims.

E. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch (6.4 mm) thick, selected from manufacturer's standard widths to match width of bottom track or rim track members.

F. Provide double neoprene sway braces for resilient indirect attachment between acoustically isolated structures. Provide sway braces only at head and other necessary attachment points as indicated on drawings and in accordance with requirements indicated by the Project Structural Engineer.
   1. Acceptable product: mason Industries Type DNSB or approved equal.

2.09 FABRICATION

A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.
   1. Fabricate framing assemblies using jigs or templates.
   2. Cut framing members by sawing or shearing; do not torch cut.
   3. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
      a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
      b. Locate mechanical fasteners and install according to Shop Drawings, with screw penetrating joined members by no fewer than three exposed screw threads.
   4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to Shop Drawings.

B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.

C. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
   1. Spacing: Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
   2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine supporting substrates and abutting structural framing 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. Install load bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch (6 mm) to ensure a uniform bearing surface on supporting concrete or masonry construction.

B. Install sealer gaskets at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.03 INSTALLATION, GENERAL

A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.

B. Install cold-formed steel framing according to AISI S200 and to manufacturer's written instructions unless more stringent requirements are indicated.

C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
   1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch (1.6 mm).

D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
   1. Cut framing members by sawing or shearing; do not torch cut.
   2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.
      a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
      b. Locate mechanical fasteners and install according to Shop Drawings, and complying with requirements for spacing, edge distances, and screw penetration.

E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.

F. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.

G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.

H. Install insulation in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.

I. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

J. Erection Tolerances: Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
   1. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.04 INTERIOR LOAD-BEARING WALL INSTALLATION

A. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure as indicated.

B. Fasten both flanges of studs to top and bottom track unless otherwise indicated. Space studs as follows:
   1. Stud Spacing: As indicated.

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.

D. Install horizontal bridging in wall studs, spaced vertically in rows but not more than 48 inches (1220 mm) apart. Bridging at wall studs is not required where the studs are sheathed on both sides for the full height of the wall. Where sheathing on one side doesn't continue the full height of the wall, bridging is required. Fasten at each stud intersection.
   1. Bridging: Cold-rolled steel channel, mechanically fastened to webs of punched studs using bridging clips.
   2. Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
   3. Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.

E. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

F. Fully seat load-bearing wall studs in bottom and top tracks with gaps of 1/8" or less.

3.05 JOIST INSTALLATION

A. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners, ends, and spacings indicated on Shop Drawings.

B. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
   1. Install joists over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm).
   2. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections as indicated on Contract Drawings.

C. Space joists not more than 2 inches (51 mm) from abutting walls, and as follows:
   1. Joist Spacing: As indicated.

D. Frame openings with built-up joist headers consisting of joist and joist track, or another combination of connected joists if indicated.

E. Install bridging at intervals indicated. Fasten bridging at each joist intersection as follows:
   1. Bridging: Joist-track solid blocking of width and thickness indicated, secured to joist webs.

F. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.

G. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

3.06 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Field and shop welds will be subject to testing and inspecting.

C. Testing agency will report test results promptly and in writing to Contractor and Architect.

D. Remove and replace work where test results indicate that it does not comply with specified requirements.

E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.07 REPAIRS AND PROTECTION

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION

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SECTION 05 50 00

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Custom fabricated metal items and certain manufactured units not otherwise indicated to be provided under work of other specification sections.
   2. Seat angle frames
   3. Fall arrest anchors
   4. Iron castings
   5. Ladders, ladder cages, and safety posts
   6. Ladder Rail Fall Protection System
   7. U-channel concrete inserts
   8. Cover plates and frames
   9. Pipe sleeves
   10. Bollards
   11. Stairs
   12. Safety nosings at concrete stairs
   13. Miscellaneous metal fabrications not covered elsewhere

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 05 05 14 Hot-Dip Zinc Coating
   3. Section 05 05 20 Anchor Bolts
   4. Section 05 10 00 Structural Metal Framing
   5. Section 05 52 10 Aluminum Railings
   6. Section 05 53 10 Metal Gratings and Stair Treads
   7. Section 09 90 00 Painting and Coating

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 360	Specification for Structural Steel Buildings
AISC Steel Construction Manual	American Institute of Steel Construction, Manual of Steel Construction
ANSI A14.3	Standard for Ladders - Fixed - Safety Requirements
ASTM A36	Carbon Structural Steel
ASTM A48	Gray-Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123	Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A240	Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Stainless Steel Bars and Shapes
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60000 psi Tensile Strength
ASTM A312	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320	Alloy-Steel Bolting Materials for Low Temperature Service
ASTM A325	Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A489	Carbon Steel Lifting Eyes
ASTM A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A554	Welded Stainless Steel Mechanical Tubing
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A653	Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvannealed) by the Hot Dip Process
ASTM A780	Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
ASTM A786	Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
ASTM A793	Rolled Floor Plate, Stainless Steel
ASTM A924	Steel Sheet, Metallic-Coated by Hot-Dip Process
ASTM A992	Structural Steel Shapes
ASTM A1011	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B210	Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B211	Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire

Reference	Title
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM B429	Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM B632	Aluminum-Alloy Rolled Tread Plate
ASTM D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM F436	Hardened Steel Washers
ASTM F468	Nonferrous Bolts, Hex Cap Screws, SocketHead Cap Screws and Studs for General Use
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS D1.1	Structural Welding Code - Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code - Stainless Steel
OSHA 29 CFR 1910.27	Fixed Ladders
OSHA 29 CFR 1926.502	Fall Protection Systems Criteria and Practices
SSPC SP5	White Metal Blast Cleaning
IBC	International Building Code

1.04 DEFINITIONS

A. Galvanize: Hot-dip galvanize per ASTM A123 or ASTM A153, per Section 05 05 14.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
   4. Manufacturer's product data.
   5. Product Data for Recycled Content: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
   6. Detailed Shop Drawings:
      a. Fabrication drawings showing layouts, connections to structural system, and anchoring details.

b. Erection and installation drawings indicating thickness, type, grade, class of metal, coating system and dimensions.
c. Construction details, reinforcement, anchorage, and installation with relation to the building construction.

7. Welding procedures and welder certificates and qualifications.
8. U-Channel Concrete Inserts: Manufacturer's product description and allowable load tables.
9. Passivation method for stainless steel fabrications.
10. Fall Arrest Anchor Certificate:
    a. Certify fall arrest system is designed to meet OSHA 29 CFR 1926.502 specified performance requirements.
    b. Signed and sealed by a Professional Engineer licensed in the state in which the project is located.

1.06 QUALITY ASSURANCE

A. Qualifications
   1. Fabricator shall have a minimum of five years experience in fabrication of metal specified.

B. Certificates
   1. Certified welding procedures and welding operators in accordance with AWS. Welding operator certificates shall be no more than one-year old and the welder shall have used the welding process to be performed within the last six months.

C. The use of salvaged, reprocessed or scrap materials will not be permitted.

D. Shop Assembly: Items in the shop shall be preassembled to the greatest extent possible, so as to minimize field splicing and assembly of units. Units shall be disassembled only to the extent necessary for shipping and handling limitations. Units shall be clearly marked for reassembly and coordinated installation.

1.07 DELIVERY, STORAGE AND HANDLING

A. Avoid damage during delivery and handling of fabrications.

B. Store off the ground on skids or other supports to keep items free of dirt and other foreign debris and to protect against corrosion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than the following:
   1. W-Shapes: 60 percent.
   2. Channels, Angles: 60 percent.
   3. Plate and Bar: 25 percent.

4. Cold-Formed Hollow Structural Sections: 25 percent.
5. Steel Pipe: 25 percent.
6. All Other Steel Materials: 25 percent.

B. Materials for miscellaneous metalwork are specified in the following table.

Material	Specification
Steel	
• Sheets, plates and shapes (except W shapes)	ASTM A36
• W shapes	ASTM A992
• Pipe	ASTM A53, Grade B
• Square/rectangular tubing	ASTM A500, Grade B
• Headed Anchor Studs	ASTM A108
• Carbon steel bolts	ASTM A307, Grade A
• High strength bolts	ASTM A325 (Type 1)
• Nuts	ASTM A563
• Washers	ASTM F436
Stainless Steel	
• Sheet and Plates	ASTM A240, Type 316 or 316L
• Shapes, bars, and similar items	ASTM A276, Type 316 or 316L
• Pipe	ASTM A312, Type 316 or 316L
• Headed Anchor Studs	ASTM A276, Type 316L
• Bolts	ASTM F593, Type 316
• Nuts	ASTM F594, Type 316
Aluminum	
• Sheets and plates	ASTM B209, Type 6061-T6
• Bars, flats and similar items	ASTM B211 or B221, Type 6061-T6
• Shapes	ASTM B308, Type 6061-T6
• Round tubing and pipe	ASTM B241, Type 6061-T6
• Square and rectangular tubing	ASTM B221, Type 6063-T52
• Pipe	ASTM B211 or B241, Type 6061-T6
• Bolts, Stainless Steel	ASTM F593, Type 316
• Nuts, Stainless Steel	ASTM F594, Type 316
Checker Plate	
• Steel	ASTM A786
• Stainless steel	ASTM A793, Type 304
• Aluminum	ASTM B632, Type 6061-T6
Other steel items	
• Iron castings	ASTM A48
• Eyebolts	ASTM A489
• Threaded rods	ASTM A36

2.02 FABRICATION

A. General
   1. Conform to AISC or Aluminum Association standards as applicable. Where Code defined loads apply, also conform to IBC requirements.
   2. Shop and field welding shall conform to the requirements of AISC, the Aluminum Design Manual, and applicable AWS procedures and specifications as required by the material being welded.
   3. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt, tight, flush, and hairline. Remove burrs and weld splatter. Ease exposed edges to small uniform radius.
   4. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Whenever needed, because of the thickness of the metal, holes shall be subpunched and reamed or shall be drilled.
   5. Fabrication, including cutting, drilling, punching, threading and tapping required for fabrications or adjacent work, shall be performed prior to galvanizing.

B. Seat Angle Frames
   1. Provide recessed seat angle frames for grating and floor plates. Miter corners to ensure accurate fit. Match depth of recess with grating or floor plate thickness. Anchor frames in concrete with headed studs. Steel angle support frames shall be stainless steel, ASTM A276, Type 316, unless indicated otherwise.

C. Fall Arrest Anchors
   1. Fall arrest anchors shall meet requirements of OSHA 29 CFR 1926.502. Anchorages attached to personal fall arrest equipment shall be capable of supporting at least 5,000 pounds per employee attached, or shall be designed, installed, and used as part of a complete personal fall arrest system which maintains a safety factor of at least two. Type of anchor shall fit the application and substrate material.
   2. Fall arrest anchors shall be manufactured by:
      a. Thaler Metal Industries
      b. DBI-SALA
      c. Approved Equal

D. Iron Castings
   1. Castings shall be as specified on the Drawings. Castings weighing less than 100 pounds shall be galvanized after machining. Castings weighing greater than 100 pounds shall be galvanized where specified.

E. Ladders
   1. Aluminum Ladders: Ladders shall be vendor supplied pre-engineered aluminum ladders. Ladders shall be fabricated of alloy 6063-T6. Rungs shall have non-slip grip surface. Finish shall be anodized. Fabricate ladders with rails, rungs, landings and cages to meet applicable requirements of OSHA 29 CFR 1910.27. Rungs shall be a minimum clear length of 16 inches, uniformly spaced at a maximum of 12 inches and plug welded into side rails. Install ladders so that the distance from the centerline of rungs to the finished wall surface is not less than 7 inches nor more than 12 inches. Provide clip angle supports bolted to the side rail at the top. Provide intermediate clip angle lateral supports at a maximum of 10 feet on center.

2. Ladder Safety Post:
    a. Provide a telescoping ladder safety post at ladders below all floor and roof hatches, and other coverings.
    b. The ladder safety post shall be pre-assembled from the manufacturer.
    c. Performance characteristics:
        1) Post shall lock automatically when fully extended.
        2) Post shall have controlled upward and downward movement.
        3) Release lever shall disengage the post to allow it to be returned to its lowered position.
        4) Post shall have adjustable mounting brackets to fit ladder rung spacing up to 14" on center and clamp brackets to accommodate ladder rungs up to 1-3/4" in diameter.
        5) Post: Manufactured of high strength square tubing with a pull up loop provided at the upper end of the post to facilitate raising the post.
        6) Material of construction: Aluminum
        7) Balancing spring: Stainless steel spring balancing mechanism to provide smooth, easy, controlled operation when raising and lowering the safety post.
    d. Acceptable products include:
        1) LadderUp Safety Post by Bilco
        2) Ladder Safety Post Model SP by Nystrom Inc.
        3) Approved equal
3. Ladder Cages:
    a. Provide ladder cages when ladders are greater than 20 feet tall between floor/landing surfaces. Conform to OSHA 29 CFR 1910.27.
4. Ladder Rail Fall Protection System:
    a. System shall consist of a vertical rigid track carrier rail securely and permanently attached to ladder, over which travels a sleeve to harness belt can be attached.
    b. Rail:
        1) Notched at six-inch intervals and constructed of stainless steel Type 316.
        2) Provide ladder attachments/rail mounting brackets of same material as rail, and as required by Supplier.
        3) For all ladders, include provisions to secure safety sleeve to carrier rail at top of vertical ladder so that sleeve will not slide down rail when safety belt is unsnapped.
        4) Ladders Below Hatches: Rail for ladder shall extend from bottom of ladder to top of ladder. Provide telescopic safety post.
        5) Ladders Not Below Hatches: Rail for ladder shall extend from bottom of ladder to above horizontal landing or roof at top of ladder. Provide removable extension section at top of ladder. Arrange rail to allow climber to land on landing or roof without unsnapping climber's safety harness.
    c. Accessories: Provide with each ladder the following, all furnished by the fall prevention system Supplier:
        1) One safety sleeve compatible for use with the rail. Sleeve shall be cast bronze with five zinc plated steel roller bearings. Sleeve shall travel smoothly on straight or curved rail.

2) One safety harness that attaches to sleeve. Harness shall be of woven high-strength nylon, with padded straps and forged steel buckles and rings. Harness shall distribute impact forces of a fall over climber's thighs, buttocks, chest, and shoulders.

3) One shock adsorbing lanyard no longer than six-feet, complying with ANSI Z359.1. Lanyard shall be 5/8-inch diameter nylon rope with double locking hooks at each end.

d. Acceptable ladder rail fall protection systems include:

1) Miller Saf-T-Climb as manufactured by Honeywell

2) Vertical Rigid Track Fall Arrest System as manufactured by Diversified Fall Protection

3) Approved equal

F. U-Channel Concrete Inserts

1. U-Channel Concrete Inserts shall be stainless steel conforming to attachment hardware and materials attached. Channels shall be 1 5/8 inch wide by 1 3/8 inch deep with a minimum thickness of 0.105 inches. Channels shall be open-bottom with curved or lipped flange edges to engage standard nuts and connection hardware. Load rating shall meet or exceed a 2,000 pound point load at 12 inch minimum spacing. Provide standard accessories and hardware per manufacturers recommendations.

G. Cover Plates and Frames

Fabricate aluminum cover plates weighing not more than 80 pounds per cover with a raised pattern nonslip top surface conforming to ASTM B632. Reinforce to sustain a live load of 100 pounds per square foot (foot traffic only) or as indicated on the Drawings. Frames shall be stainless steel angles and plates, with stainless steel

headed anchors welded to frame for anchoring to concrete. Miter and weld corners and butt joint straight runs. Provide flush drop handles for removal. Remove sharp edges and burrs from cover plates and exposed edges of frames. Weld connections and grind top surface smooth. Provide 1/8 inch clearance at edges.

H. Pipe Sleeves

1. Unless otherwise indicated on the Drawings, fabricate pipe sleeves from schedule 40 steel pipe with 3/16 inch thick by 3 feet wide seep ring continuously seal welded to the outside of the pipe. Galvanize after fabrication in accordance with ASTM A123.

I. Bollards

1. Provide minimum 6 inch galvanized standard weight steel pipe or as indicated on the Drawings. Pipe to be in accordance with ASTM A53. Anchor posts in concrete and fill solidly with concrete of a minimum compressive strength of 2500 psi. Coat galvanized pipe above grade in accordance with Section 09 90 00. Top coat cover color shall be safety yellow.

J. Stairs – Galvanized Steel

1. Provide galvanized steel stairs complete with stringers, metal-pan concrete-filled treads, grating treads, landings, columns, guardrails, handrails, and necessary bolts and other fastenings. Hot-dip galvanize steel stairs and accessories.

2. Fabricate stringers of structural steel channels. Provide closures for exposed ends of stringers. Construct landings of structural steel channel headers and miscellaneous framing members as indicated.
3. Grating Treads and Landings: Provide galvanized grating conforming to Section 05 53 10. Fabricate grating treads with abrasive nosing and with steel angle or plate carrier at each end for string connections. Secure treads to stringers with bolts. Fabricate grating landings with nosing that matches grating treads. Provide toe-plates at open-sided edges of landing.
4. Metal-Pan Concrete-Filled Treads: Form metal pans of 12-gage thick structural steel sheets, conforming to ASTM A1011, Grade 36. Shape pans to configuration indicated. Construct riser and subtread metal pans with steel angle supporting brackets, of size indicated, welded to stringers. Secure metal pans to brackets with welds. Cast metal abrasive safety nosings into concrete fill at tread and landing.
5. Provide railings for stairs and landings in accordance with Section 05 52 10 *or* 05 52 20.

K. Stairs – Aluminum
1. Provide aluminum stairs complete with stringers, grating treads, landings, columns, guardrails, handrails, and necessary bolts and other fastenings.
2. Fabricate stringers of structural aluminum channels. Provide closures for exposed ends of stringers. Construct landings of structural channel headers and miscellaneous framing members.
3. Grating Treads and Landings: Provide aluminum grating for treads and landings conforming to Section 05 53 10. Fabricate grating treads with abrasive nosing and with angle or plate carrier at each end for stringer connections. Secure treads to stringers with bolts. Fabricate grating landings with nosing that matches grating treads. Provide toe-plates at open-sided edges of landing.
4. Provide railings for stairs and platforms in accordance with Section 05 52 10.

L. Safety Nosings at Concrete Stairs
1. Safety stair treads shall be 4 inches wide and manufactured by:
   a. Safe T Metal Company Incorporated, Style AX;
   b. Wooster Products Incorporated, Alumogrit, Type 101;
   c. Approved Equal.

M. Other Miscellaneous Steel Metalwork
1. Other miscellaneous steel metalwork including embedded and non-embedded steel metalwork, hangers and inserts shall be as specified or shown on the Drawings, and shall be galvanized after fabrication unless otherwise noted.

2.03 FINISHES

A. Galvanizing
1. Galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing in accordance with ASTM A123, ASTM A153, ASTM A653 or ASTM A924, Z275 G90, as applicable. Galvanize anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2. Repair damaged Zinc-Coated surfaces with galvanizing repair method and paint conforming to ASTM A780 or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Owner's Representative.
3. Safeguard against warpage and distortion during galvanizing of steel in accordance with ASTM A384. Straighten items after galvanizing so that they are straight, free of racking and distortion.

B. Shop Painting
1. Prepare and coat surfaces in accordance with Section 09 90 00.
2. Steel to be embedded in concrete shall be free of dirt and grease.

C. Aluminum Surfaces
1. Surface condition aluminum before finishes are applied. Remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.
2. Aluminum finishes for unexposed sheet, plate and extrusions may have mill finish as fabricated.
3. Provide other aluminum items with a standard mill finish.
4. Provide a coating thickness not less than that specified for protection.
5. Provide decorative type finishes for items used in interior occupied locations or architectural type finish for items used in exterior locations.
6. Provide a polished satin finish on items to be anodized.

D. Stainless Steel Passivation
1. Stainless steel to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380. Passivate to remove iron compounds from the surface of the stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify measurements at the site. Include field dimensions in shop drawings.

B. Examine and accept existing conditions before beginning work.

3.02 PREPARATION

A. Make provisions for erection loads with temporary bracing. Keep work in alignment.

B. Supply items required to be cast into concrete or embedded in masonry with setting templates.

3.03 INSTALLATION

A. Install items plumb, level and square, accurately fitted, and free from distortion or defects. Install rigid, substantial, and neat in appearance.

B. Allow for erection loads and provide temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Fieldwork shall not be permitted on galvanized items. Drilling of bolts or enlargement of holes to correct misalignment will not be allowed.

D. Protect encased or embedded dissimilar metals (both metals must be encased or embedded) from galvanic corrosion by means of pressure tapes, coatings or isolators.

E. Place metalwork to be embedded in concrete accurately and hold in correct position while the concrete is placed or, if indicated, form recesses or blockouts in the concrete. Thoroughly clean the surfaces of metalwork in contact with or embedded in concrete.

F. Seat angles, supports and guides: Set seat angles for grating and supports for floor plates so that they maintain the grating and floor plates flush with the floor.

G. Ladder Safety Post: Comply with manufacturer's installation instructions.

H. Pipe Sleeves: Provide where pipes pass through concrete or masonry. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls. Provide a center flange for water stoppage on sleeves in exterior or water bearing walls. Provide a rubber caulking sealant or a modular mechanical unit to form a watertight seal in the annular space between pipes and sleeves.

I. U-Channel Concrete Inserts: Provide as indicated for pipe supports and where otherwise specified or shown on Drawings.

J. Safety Nosings: Unless otherwise specified, safety stair nosing shall be installed on concrete stairs. Nosing shall be secured to concrete with suitable anchors at 15 inches on center and not more than 4 inches from the ends. 1/8 inch thick rubber tape shall be provided at both ends and cut to fit shape of nosing prior to concrete placement.

K. Concrete: Pan-filled stairs to be constructed in accordance with Section 03 30 00. Finish concrete with a "nonslip" finish with "very flat" tolerance as specified in ACI 301.

L. Fastening to Construction-In-Place: Provide anchorage devices and fasteners where necessary for fastening fabricated items to construction-in-place. Design anchorage devices in accordance with Section 01 73 24. Anchor bolts to be in accordance with Section 05 05 20.

M. Set steel stair baseplates on wedges, or shims. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims, but if protruding, cut off flush with edge of bearing plate before packing with grout.

N. Railing: Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing required by design loads and as limited on Drawings. Plumb posts in each direction.

3.04 REPAIR/RESTORATION

A. Galvanized
   1. Maximum area to be repaired shall not be more than 1/2 of 1 percent of the surface area or 36 sq. in. per ton of piece weight, whichever is less. Damage in excess of this requirement shall be repaired by stripping and recoating entire piece.
   2. Clean damaged areas to SSPC-SP5. Repair with zinc-rich paint in accordance with the manufacturer's instructions and with ASTM A780, Annex A2. Minimum thickness requirements shall be in accordance with ASTM A123.
   3. Use zinc-rich repair paint. Acceptable manufacturers:
      a. LPS, Cold Galvanize
      b. ZRC Worldwide, ZRC Galvilite
      c. Approved Equal

B. Painted
   1. After installation, clean and touch up damaged areas with the same materials used for the shop coat.

3.05 FIELD QUALITY CONTROL

A. Electrolytic Protection

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Aluminum in contact with concrete or grout shall be protected with a heavy coat of bituminous paint.

C. Stainless Steel
   1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
   2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
   3. Remove contamination in accordance with requirements of ASTM A380.
   4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.

END OF SECTION

SECTION 05 52 10

ALUMINUM RAILINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Prefabricated anodized aluminum component type guardrail and handrail systems; herein referred to as railing.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-in-Place Concrete.

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B210	Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B429	Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM B483	Aluminum and Aluminum-Alloy Drawn Tube and Drawn Pipe for General Purpose Applications
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS D1.2	Structural Welding Code, Aluminum
OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration
IBC	International Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Layout, installation, and detail shop drawings for railing.
5. Design calculations stamped and signed by a licensed professional engineer in the State of Utah. Railing and base support connections to be designed by the Contractor incorporating specified criteria and provisions in the current building code with local governing amendments.

B. Informational Submittals:
1. Material certification for compliance with this specification for aluminum and stainless steel materials.

1.05 QUALITY ASSURANCE

A. General:
1. Railing shall conform to the standards of the Occupational Safety and Health Administration (OSHA) and International Building Code.

1.06 DELIVERY, STORAGE AND HANDLING

A. Cushion wrap complete rails, modules and components to prevent scratching and denting during shipment, storage, and installation.

B. Leave wrap intact, insofar as possible, until railing is completely installed.

PART 2 PRODUCTS

2.01 PERFORMANCE/DESIGN CRITERIA

A. Railing assembly and attachments shall resist a minimum uniform load of 50 pounds per linear foot on the top rail and a concentrated load of 200 pounds (not acting concurrently with the uniform load) applied in any direction. Contractor's supplier and engineer are responsible for designing the guardrail/handrail system along with its base support and anchor bolt size and embedment depth into concrete, or connection to metal framing, to resist the above loading condition taking into account anchor edge distances and concrete strengths at the point of attachment. Contractor shall submit calculations signed and sealed by a professional engineer in the State of Utah.

B. Thermal Movements: Provide railing that allow for thermal movements resulting from the project site maximum range in ambient and surface temperatures. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.

2.02 MANUFACTURERS

A. Julius Blum & Co., Inc.

B. Golden Railing Inc.

C. Moultrie Manufacturing.

D. American Railing Systems, Inc.

E. Approved equal.

2.03 MATERIALS

Component	Material
Aluminum pipe	ASTM B210 Alloy 65060-T832; ASTM B 221 Alloy 6063-T5/T52; ASTM B 429, Alloy 6063-T832; ASTM B483, Alloy T832
Aluminum plate	ASTM B209, Alloy 6061-T6
Stainless steel bolts	ASTM A593, Type 316
Stainless steel nuts and washers	ASTM A594, Type316

2.04 CONFIGURATION/COMPONENTS

A. Guard Top Rails: Minimum 1 1/2 inch nominal diameter pipe, Schedule 40.

B. Intermediate Rails: Minimum 1 1/2 inch nominal diameter pipe, Schedule 40.

C. Handrails: 1 1/2 inch nominal diameter pipe, Schedule 40.

D. Posts: Minimum 1 1/2 inch nominal diameter pipe, Schedule 80.

E. Provide manufacturer’s heavy-duty base fitting with stainless steel set screws.

F. Provide aluminum toe boards at guardrails, except where concrete curbs are indicated. Aluminum toe boards shall be minimum 3/16-inch thick plate, connected to the posts.

G. Bolts, including anchor bolts, shall be Type 316 stainless steel.

H. Fittings:
   1. Fittings shall be cast aluminum elbows, T-shapes, post brackets and escutcheons. Provide adapter and anchor plugs as required for a complete installation.
   2. Floor sleeves for removable railing shall be stainless steel, embedded in concrete.

2.05 ASSEMBLY/FABRICATION

A. Pipe cuts shall be clean, straight, square and accurate for minimum joint gap. Work shall be done in conformance with the guardrail and handrail manufacturer's instructions. Work shall be free from blemishes, defects, and misfits of any type which can affect durability, strength, or appearance.

B. Guardrailing and handrailing shall be connected by screws or bolts or welding. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Wherever needed because of the thickness of the metal, holes shall be subpunched and reamed or drilled. Components with mismatched holes shall be replaced. No drifting of bolts or enlargement of holes will be allowed to correct misalignment.

C. Supply components required for anchorage of fabrications.

D. Where shop welding is used, grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints tight and flush. Round exposed edges to small, uniform radius. Use filler alloy rods that will not discolor when anodized, such as ER 5154, ER 5254, ER 5183, ER 5356 or ER 5556 filler alloy rods.

2.06 ISOLATION COATING

A. Isolation coating shall be applied to all aluminum surfaces in contact with concrete, masonry, or dissimilar metals. Use a heavy coat of bituminous paint.

2.07 FINISHES

A. Clear anodized in accordance with the Aluminum Association AA-M12-C22-A41. Anodize exposed prefabricated components, except stainless steel fasteners, after fabrication.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

B. Field verify measurements for railings before fabrication.

3.02 INSTALLATION

A. Install in accordance with manufacturer's written instructions.

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Aluminum in contact with concrete or grout shall be protected with a heavy coat of bituminous paint.

C. Accurately place metal to be embedded in concrete and hold in correct position while the concrete is placed. Where recesses or blockouts are formed in the concrete, grout metalwork in place after concrete has attained its design strength in accordance with Section 03 30 00.

D. Unless otherwise indicated, field welding of railing is not permitted.

3.03 TOLERANCES

A. Maximum variance from plumb: 1/4 inch.

B. Maximum offset from true alignment: 1/4 inch.

END OF SECTION

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SECTION 05 53 10

METAL GRATINGS AND STAIR TREADS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Aluminum, galvanized steel, and stainless steel bar grating and stair treads.

1.02 RELATED SECTIONS

A. This section contains references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete.
   2. Section 05 05 14 Hot-Dip Zinc Coating.

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM A123	Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A380	Cleaning, Descaling, and Passivation of Stainless Steel
[ASTM A666	Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
[ASTM A1011	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, and High- Strength Low-Alloy]
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ANSI/NAAMM	Metal Bar Grating Design Manual

1.04 DEFINITIONS

A. Galvanize: Hot-dip galvanize per ASTM A123 or ASTM A153, per Section 05 05 14.]

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   1. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

2. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Shop drawings showing placing plans for grating.
    a. Provide layout and fabrication details of support frames.
    b. Provide panel layout with individual panel dimensions.
4. Manufacturer's product data with load tables.

PART 2 PRODUCTS

2.01 MATERIALS

Component	Material
Aluminum grating bearing and cross bars	ASTM B221, alloy 6061
[Steel grating bearing and cross bars	ASTM A1011, mild carbon steel]
[Stainless steel grating	ASTM A167 or A666, alloy 316L]

2.02 ASSEMBLY/FABRICATION

A. Welds:
    1. Grind smooth rough welds and sharp metal edges. Make welds exposed to view uniform and neat.
    2. [Prior to galvanizing, sandblast welds.]

B. Clearance: provide ¼" separation between panels and at bearing ends of panel to support frame.

C. Grating:
    1. General
        a. Provide serrated grating for slip resistance.
        b. Bearing bars and cross bars are continuous.
        c. Openings shall be banded with bars having the same dimensions as the bearing bars. Band perimeter edges with bars flush at the top surface of the grating and 1/4 inch clear of the bottom surface.
        d. Bars terminating against edge bars shall be welded to the edge bars when welded construction is used.
        e. When crimped or swaged construction is used, bars at edges shall protrude a maximum of 1/16 inch and be peened or ground to a smooth surface.
        f. Fabrication methods employing bending or notching of bearing or cross bars is not permitted.
        g. Maximum grating panel weigh shall not exceed 80 pounds.

2. Aluminum Grating
    a. Fabricate grating with a mill class 1 clear anodize finish. Punch bearing bars to receive cross bars. After insertion in the bearing bars, cross bars are deformed by a hydraulic press or similar means to permanently lock the bars into the bearing bar openings.
3. Steel Grating
    a. Use only where specified. Hot-dip galvanized finish after fabrication.
4. Stainless Steel Grating
    a. Use only where specified. Stainless steel grating to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380.

D. Stair Treads:
1. Treads shall match the grating material and type furnished for landings. Use serrated surface for slip resistance. Provide abrasive nosings on each tread. Provide carrier angle at each end for attachment to stair stringers. Attach components to support members with Type 316 stainless steel fasteners.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

B. Field measure grating for proper cutouts and sizes prior to fabrication.

3.02 INSTALLATION

A. Fieldwork is not permitted on galvanized items.

B. Drilling of bolts or enlargement of holes to correct misalignment is not permitted.

C. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Protect aluminum in contact with concrete with a heavy coat of bituminous paint.

D. Use stainless steel metalwork to be embedded in concrete. Clean surfaces in contact with or embedded in concrete and hold in correct position while concrete is placed. Or, provide formed recesses or blockouts in concrete and then, after concrete has attained design strength, grout metalwork in-place using non-shrink grout.

3.03 [REPAIR

A. Repair damaged surfaces of galvanized metals per Section 05 05 14.

END OF SECTION

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SECTION 06 10 00

ROUGH CARPENTRY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Wood blocking, cants, and nailers.
   2. Wood furring and grounds.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. For each type of process and factory-fabricated product.
   2. For preservative-treated wood products.

1.03 INFORMATIONAL SUBMITTALS

A. Material Certificates:
   1. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

B. Evaluation Reports: For the following, from ICC-ES:
   1. Wood-preservative-treated wood.
   2. Fire-retardant-treated wood.

PART 2 PRODUCTS

2.01 WOOD PRODUCTS, GENERAL

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. Dress lumber, S4S, unless otherwise indicated.

B. Maximum Moisture Content:
   1. Boards: 19 percent.
   2. Dimension Lumber: 19 percent unless otherwise indicated.

2.02 PRESERVATIVE TREATMENT

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.
   1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.

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.

D. Application: Treat all rough carpentry unless otherwise indicated.
   1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
   2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
   3. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.

2.03 FIRE-RETARDANT-TREATMENT

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 according to 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 beyond the centerline of the burners at any time during the test.
   1. 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 according to ASTM D2898. Use for exterior locations and where indicated.
   2. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested according to ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.

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.

E. Application: Treat all rough carpentry unless otherwise indicated.
   1. Concealed blocking.
   2. Roof construction.

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. Cants.
   4. Furring.
   5. Grounds.

B. Dimension Lumber Items: Construction or No. 2 grade lumber, Douglas Fir.

C. Concealed Boards: 19 percent maximum moisture content and the following species and grades:
   1. Western woods; Construction or No. 2 Common grade; WCLIB or WWPA.

2.05 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 into wood substrate.
   1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

2.06 MISCELLANEOUS MATERIALS

A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber or rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch.

B. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D3498 that is approved for use indicated by adhesive manufacturer.

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 furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

B. Do not splice structural members between supports unless otherwise indicated.

C. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

D. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

E. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
   1. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code (IBC).
   2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
   3. ICC-ES evaluation report for fastener.

3.02 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION

SECTION 06 16 00

SHEATHING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Wall sheathing.
   2. Composite nail base insulated roof sheathing.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product.

1.03 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For the following, from ICC-ES:
   1. Wood-preservative-treated plywood.
   2. Fire-retardant-treated plywood.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Fire-Resistance Ratings: As tested in accordance with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

B. Structural Performance: Provide roofing systems capable of withstanding the effects of the following loads:
   1. Wind Loads: As indicated on Drawings.
   2. Deflection Limits: For wind loads, no greater than 1/240 of the span.

C. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

2.02 PRESERVATIVE-TREATED PLYWOOD

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.

B. Mark plywood with appropriate classification marking of an inspection agency acceptable to authorities having jurisdiction.

C. Application: Treat all plywood unless otherwise indicated.

2.03 FIRE-RETARDANT-TREATED PLYWOOD

A. General: Where fire-retardant-treated materials are indicated, use materials complying 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 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 beyond the centerline of the burners at any time during the test.

1. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.
2. Design Value Adjustment Factors: Treated lumber plywood is to be tested in accordance with ASTM D5516 and design value adjustment factors are to be calculated in accordance with ASTM D6305. Span ratings after treatment are to be not less than span ratings specified.

C. Kiln-dry material after treatment to a maximum moisture content of 15 percent.

D. Identify fire-retardant-treated plywood with appropriate classification marking of qualified testing agency.

E. Application: Treat all plywood unless otherwise indicated.

2.04 WALL SHEATHING

A. Plywood Sheathing, Walls: Either DOC PS 1 or DOC PS 2, Exposure 1, Structural I sheathing.

2.05 COMPOSITE NAIL BASE INSULATED ROOF SHEATHING

A. Plywood-Surfaced, Polyisocyanurate-Foam Sheathing: ASTM C1289, Type V with DOC PS 2, Exposure 1 Fire-Resistant-Treated CDX plywood on one face.

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. Atlas Molded Products, a division of Atlas Roofing Corporation.
   b. Cornell Performance Building Products, a Subsidiary of GAF.
   c. Johns Manville; a Berkshire Hathaway company.
   d. Rmax, Inc.
   e. The Dow Chemical Company.
   f. Polyisocyanurate-Foam Thickness: 3 inches; one layer composite nail base insulated roof sheathing and one layer insulation only, 6 inches total.

2. Plywood Nominal Thickness: 5/8 inch.

2.06 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
   1. For roof sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

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. Coordinate roof 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.

E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

END OF SECTION

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SECTION 07 11 13

BITUMINOUS DAMPPROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Cold-applied, emulsified-asphalt dampproofing.
   2. Protection course.
   3. Drainage board.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. VOC Content: Products are to comply with VOC content limits of authorities having jurisdiction unless otherwise indicated.

2.02 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; Sealmastic Emulsion or a comparable product by one of the following:
   1. ChemMasters, Inc.
   2. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
   3. Retain one or more of "Trowel Coats," "Fibered Brush and Spray Coats," and "Brush and Spray Coats" paragraphs below; coordinate with applications retained in Part 3.

B. Trowel Coats: ASTM D1227, Type II, Class 1.

C. Fibered Brush and Spray Coats: ASTM D1227, Type II, Class 1.

D. Brush and Spray Coats: ASTM D1227, Type III, Class 1.

2.03 PROTECTION COURSE

A. Protection Course, Asphaltic: ASTM D6506/D6506M; semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
   1. Thickness: Nominal 1/8 inch for vertical applications.
   2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for protection course type.

2.04 DRAINAGE BOARD

A. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; MEL-DRAIN 7955-B or a comparable product by one of the following:
   1.
   2. ChemMasters, Inc.
   3. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
   4. Geocomposite Drainage Board: ASTM D6364 or ASTM D162, High strength dimple raised molded polypropylene core with a high strength woven geotextile fabric bonded to the dimples of the core. Attached to the back side of the dimples is a polyethylene sheet designed to prevent soft waterproofing membranes from working their way into the backside of the dimples.

B. Accessories:
   1. Termination Bar.
   2. Pointing Mastic.

2.05 AUXILIARY MATERIALS

A. Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.

B. Emulsified-Asphalt Primer: ASTM D1227, Type III, Class 1, except diluted with water as recommended in writing by manufacturer.

PART 3 EXECUTION

3.01 APPLICATION, GENERAL

A. Comply with manufacturer's written instructions for dampproofing application, cure time between coats, and drying time before backfilling unless otherwise indicated.
   1. Apply dampproofing to provide continuous plane of protection.
   2. Apply additional coats if recommended in writing by manufacturer or to achieve a smooth surface and uninterrupted coverage.

B. Where dampproofing footings and foundation walls, apply from finished-grade line to top of footing; extend over top of footing and down a minimum of 6 inches over outside face of footing.
   1. Extend dampproofing 12 inches onto intersecting walls and footings, but do not extend onto surfaces exposed to view when Project is completed.
   2. Install flashings and corner protection stripping at internal and external corners, changes in plane, construction joints, cracks, and where indicated as "reinforced," by embedding an 8-inch-wide strip of asphalt-coated glass fabric in a heavy coat of dampproofing. Dampproofing coat for embedding fabric is in addition to other coats required.

3.02 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Concrete Foundations: Apply two brush or spray coats at not less than 1.5 gal./100 sq. ft. for first coat and 1 gal./100 sq. ft. for second coat one fibered brush or spray coat at not less than 3 gal./100 sq. ft. or one trowel coat at not less than 4 gal./100 sq. ft..

3.03 INSTALLATION OF DRAINAGE BOARDS

A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, in accordance with manufacturer's written installation instructions. Use adhesive or another method that does not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
   1. For vertical applications, install protection course before installing drainage panels.

END OF SECTION

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SECTION 07 13 26

SELF-ADHERING SHEET WATERPROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Modified bituminous sheet waterproofing.
   2. Protection course.
   3. Drainage board.
   4. Underslab waterproofing membrane.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review waterproofing requirements including surface preparation,
   2. substrate condition and pretreatment, minimum curing period, forecasted
   3. weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, expansion joints, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, air barrier, and other termination conditions.
   1. Include setting drawings that indicate layout, sizes, sections, profiles, and joint details of pedestal-supported concrete pavers.

C. Samples: For each exposed product.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Statements: For Installer.

B. Sample warranties.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.
   1. The Contractor is responsible for the workmanship and quality of the system installation. Inspections by the Owner's Representative or the System Manufacturer's Technical Representative (TR) will not relieve or limit the Contractor's responsibilities.
   2. Installation methods shall conform to requirements of this specification. Changes in the system installation requirements will be allowed only with the written acceptance of the Owner's Representative before work commences.

3. Only personnel who are trained by the TR specifically for the system or who are approved by the coating system manufacturer (SM) specifically for the system are allowed to perform the system installation specified in this Section.
4. For repairs, provide the same products, or products recommended by the SM, as used for the original installation.
5. Identify the points of access for inspection by the Owner's Representative. Provide ventilation, ingress and egress, and other means necessary for the Owner's Representatives to safely access the work areas.
6. Conduct and inspect the work so that the system is installed as specified. Work that does not conform to the specifications shall be corrected.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 SOURCE LIMITATIONS

A. Waterproofing System: Obtain waterproofing materials, protection course, drainage boards, under-slab waterproofing from single source from single manufacturer.

2.02 MODIFIED BITUMINOUS SHEET WATERPROOFING

A. Modified Bituminous Sheet Waterproofing: Minimum 60-mil nominal thickness, self-adhering sheet consisting of 56 mils of rubberized asphalt laminated on one side to a 4-mil-thick, polyethylene-film reinforcement, and with release liner on adhesive side.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; MEL-ROL or a comparable product by one of the following:
      a. Grace Construction Products.
      b. Tremco Commercial Sealants and Waterproofing, part of Tremco CPG.
      c.
   2. Physical Properties:
      a. Tensile Strength, Membrane: 250 psi minimum; ASTM D412, Die C, modified.
      b. Ultimate Elongation: 300 percent minimum; ASTM D412, Die C, modified.
      c. Low-Temperature Flexibility: Pass at minus 20 deg F; ASTM D1970/D1970M.
      d. Puncture Resistance: 40 lbf minimum; ASTM E154/E154M.
      e. Water Absorption: 0.2 percent weight-gain maximum after 48-hour immersion at 70 deg F; ASTM D570.
      f. Water Vapor Permeance: 0.05 perm maximum; ASTM E96/E96M, Water Method.
      g. Hydrostatic-Head Resistance: 200 ft. minimum; ASTM D5385/D5385M.
   3. Sheet Strips: Self-adhering, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

2.03 UNDERSLAB WATERPROOFING MEMBRANE

A. Blindside Waterproofing Membrane: 73 mil thick, composite sheet membrane comprised of an elastomeric membrane bonded to a seven-ply plasmatic matrix and a non-woven geotextile fabric.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; PRECON or a comparable product by one of the following:
      a. Grace Construction Products.
      b. Tremco Commercial Sealants and Waterproofing, part of Tremco CPG.
      c.
   2. Physical Properties:
      a. Membrane Thickness: 73 mil
      b. Low Temperature Flexibility, ASTM D1970: Pass
      c. Resistance to Hydrostatic Head, ASTM D5385-93: 230'
      d. Elongation, ASTM D412-06: >400%
      e. Tensile Strength (film), ASTM D882: 9,200 psi
      f. Crack Cycling, ASTM C836: Pass
      g. Puncture Resistance, ASTM E154: >210 lb.
      h. Peel Adhesion to Concrete, ASTM D903: 10 lb./in
      i. Moisture Vapor Transmission, ASTM E96 (Method B): 0.0011 perms
      j. Resistance to Penetration by Pesticides, ASTM F2130, Percentage of Penetration: 0.0%
      k. Resistance to Fungi in Soil, GSA-PBS 07115 – 16 weeks: No Effect

2.04 ACCESSORIES FOR WATERPROOFING

A. Furnish accessory materials as recommended in writing by waterproofing manufacturer for intended use and compatibility with sheet waterproofing.
   1. Furnish liquid-type accessory materials that comply with VOC limits of authorities having jurisdiction.

B. Primer: Liquid waterborne primer as recommended in writing for substrate by sheet waterproofing material manufacturer.

C. Surface Conditioner: Liquid, waterborne surface conditioner as recommended in writing for substrate by sheet waterproofing material manufacturer.

D. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.

E. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.

F. Metal Termination Bars: Aluminum or stainless steel bars, approximately 1 by 1/8 inch, predrilled at 9-inch centers.

2.05 PROTECTION COURSE

A. Protection Course, Asphaltic: ASTM D6506/D6506M; semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
   1. Thickness: Nominal 1/8 inch for vertical applications.
   2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for protection course type.

2.06 DRAINAGE BOARD

A. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; MEL-DRAIN 7955-B or a comparable product by one of the following:
   1. Grace Construction Products.
   2. Tremco Commercial Sealants and Waterproofing, part of Tremco CPG.
   3. Geocomposite Drainage Board: ASTM D6364 or ASTM D162, High strength dimple raised molded polypropylene core with a high strength woven geotextile fabric bonded to the dimples of the core. Attached to the back side of the dimples is a polyethylene sheet designed to prevent soft waterproofing membranes from working their way into the backside of the dimples.

B. Accessories:
   1. Termination Bar.
   2. Pointing Mastic.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean, prepare, and treat substrates in accordance with manufacturer's written installation 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. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions.

3.02 INSTALLATION OF MODIFIED BITUMINOUS SHEET WATERPROOFING

A. Install modified bituminous sheets in accordance with waterproofing manufacturer's written installation instructions.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.

C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch-minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.
   1. When ambient and substrate temperatures range between 25 and 40 deg F, install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F.

D. Horizontal Application: Apply sheets from low to high points of decks to ensure that laps shed water.

E. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.

F. Seal edges of sheet waterproofing terminations with termination bar and sealant.

G. Install sheet waterproofing and accessory materials to tie into adjacent waterproofing.

H. Roll waterproofing membrane to firmly adhere to substrate. Roll seams and terminations.

I. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fish-mouths and blisters. Patch with sheet waterproofing extending 6 inches beyond repaired areas in all directions.

J. Immediately install protection course with butted joints over waterproofing membrane.
   1. Drainage boards may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer and installed immediately.

3.03 INSTALLATION OF DRAINAGE BOARDS

A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, in accordance with manufacturer's written installation instructions. Use adhesive or another method that does not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
   1. For vertical applications, install protection course before installing drainage panels.

3.04 INSTALLATION OF UNDERSLAB WATERPROOFING MEMBRANE – HORIZONTAL

A. Prepare subgrade prior to membrane application according to ACI 302.1R.17.

B. Ensure the fabric side of the membrane is facing up.

C. Remove release paper on 6” selvedge edge and overlap edges of additional sheet. Roll press into place.

D. For end-to-end overlap, overlap membrane 6”.

E. Apply liquid detail membrane in this area to be lapped and roll press membrane into this liquid detail membrane.

F. Apply liquid detail membrane at terminations of membrane, 12” wide, centered over the termination.

G. Embed detail fabric into this wet liquid detail membrane centered over the termination, 6” on each side of lap edge and roll press into place.

H. Apply additional liquid detail membrane on all terminations of detail fabric.

I. Inspect membrane prior to pouring of concrete for any punctures or damage.

J. Repair damaged areas as directed by the manufacturer.

K. Ensure membrane is not damaged prior to concrete pour. Ensure concrete is poured within 60 days of membrane application.

3.05 PROTECTION, REPAIR, AND CLEANING

A. Do not permit foot or vehicular traffic on unprotected membrane.

B. Protect waterproofing from damage and wear during remainder of construction period.

C. 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.

D. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.

E. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

END OF SECTION

SECTION 07 16 00

CEMENTITIOUS WATERPROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Surface preparation.

B. Application of a flexible, cementitious, waterproofing coating.

C. The general conditions, supplementary conditions and general requirements of this document apply to general contractors, sub-contractors, material suppliers, and all other persons furnishing labor and materials under this section.

1.02 WORK INCLUDED

A. Provide all labor, material, and equipment necessary to apply cementitious coating in application over concrete surfaces as shown on the contract drawings and specified herein.

1.03 RELATED SECTIONS

A. Section 03 30 00 – Cast-In-Place Concrete.

1.04 REFERENCES

A. ASTM C 672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals.

B. ASTM D412 (modified) - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.

C. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials ("Wet Cup" Procedure).

D. TT-P-1411 – Federal Specification, Paint, Copolymer-Resin, Cementitious (for Waterproofing Concrete and Masonry Walls).

E. Gemite ISO TP (Test Procedure) 005-97 - Tensile Properties of Thin Cement Composites.

1.05 QUALITY ASSURANCE

A. Contractor will provide the manufacturer’s recommended equipment, manpower, and supervision at the jobsite to install the cementitious coating in compliance with the project plans and specifications.

B. Prepare a site sample approximately 4' x 4'. This sample will be regarded as the minimum standard of workmanship acceptable for this project.

C. Installation must be carried out by an experienced contractor with an adequate number of skilled personnel, experienced in the application of the crystalline coating systems.

D. Maintain a record of the batch numbers of all materials supplied for this project.

1.06 PRE-CONSTRUCTION MEETING

A. Convene one week prior to commencing work of this section, in accordance with Section 1.05 - Quality Assurance, meeting with manufacturer's technical representative, General Contractor, and Site Engineer to review the installation procedures.

1.07 SUBMITTALS

A. Comply with Section 01 33 00 - Submittal Procedures.

B. Submit manufacturer's product data and application instructions.

1.08 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. Store cementitious coating in a clean, dry area protected from direct sunlight, weather and other damage. Store all wet materials at a temperature of not less than 44o F at all times.

C. Protect materials during handling and application to prevent damage or contamination.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Product not intended for uses subject to abuse.

B. Product must never be applied if ambient temperatures cannot be kept above 40° F during application and for 48 hours thereafter.

C. Avoid applications at temperatures above 82° F.

D. Protect surrounding surfaces from damage due to work of this trade.

E. Hot Weather Application
   1. Protect the surface against rapid evaporation of water between the finishing and the final set time.
   2. Use water misting or apply a surface evaporation retarder.

F. Cold Weather Application
   1. Apply in temperatures above freezing point.
   2. Protect the material against freezing for a minimum of 48 hours.
   3. Use electrical heaters to avoid carbonation and carbonation cracking.

PART 2 PRODUCTS

2.01 CEMENTITIOUS WATERPROOFING

A. Basis-of-Design Product: Subject to compliance with requirements, provide W. R. Meadows, Inc; CEM-KOTE FLEX ST or a comparable product by one of the following:
   1. Euclid Chemical Company.

B. ACCESSORIES
   1. Reinforcing Fabric (Woven) for cove reinforcement or entire surface application: REINFORCING FABRIC HD.
   2. Reinforcing Fabric (Non-Woven) for crack treatment: REINFORCING FABRIC NW.
   3. Bonding Mortar for coves on protruding steel and plastic pipes: CEM-KOTE BARRIER COAT 100.
   4. Thin Patching Mortar for thin repairs, including bug holes: MEADOW-PATCH T1. For spray application: CEM-KOTE FLEX ST.
   5. General Purpose Structural Repair Mortar for repairs or coves: MEADOW-CRETE GPS.
   6. Thin-Set Concrete Finishing Mortar: GEM-PLAST TC.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine surfaces to receive the flexible cementitious coating.

B. Report to owner's representative, in writing, any defects in previously prepared Work or unsatisfactory site conditions.

C. Do not begin surface preparation or application until unacceptable conditions have been corrected.

D. Starting work under this section means acceptance of the surface and previously prepared work.

3.02 SURFACE PREPARATION

A. Thoroughly clean the surface using high-pressure wash with a minimum 5,000 psi or 3,500 psi with sand brought into the nozzle.

B. Ensure all soft concrete surfaces and any bond-inhibiting materials, such as release agents, are removed.

C. Wash the surface thoroughly with water prior to the application of the cementitious coating.

D. Allow all surface water to dry off to achieve a saturated surface dry (SSD) condition.

E. To ensure proper surface preparation, a bond test should be performed in accordance with manufacturer’s instructions.

F. Surface Repair
   1. Use thin patching mortar to patch the "honeycombing" and air pockets.
   2. Use polymer-modified structural repair mortar for patching in excess of 1/4”.
   3. Uneven concrete, due to concrete form misplacement, must be chipped away and surface patched smooth.
   4. Build corner coves 2" x 2" minimum, using an overhead or vertical structural repair mortar.

G. Thin Set Concrete Restoration Mortar
   1. Hand application
      a. Apply thjn set mortar using a trowel, in a manner similar to stucco application; a “scratch” coat and the second (third) coat), and finish using a float, to obtain an “open structure” surface. Apply in strict accordance with the manufacturer’s printed instructions
   2. Spray Application
      a. Apply first a thin “scratch” coat and brush the surface to obtain continuity.
      b. Apply the second (third) coat – “wet to green condition.”
      c. Compact the material using a trowel to eliminate entrapped air and finish with float to obtain “open structure” surface.
      d. Apply in strict accordance with the manufacturer’s printed instructions
   3. Air dry cure GEM-PLAST TC for a minimum three days prior to application of flexible cementitious coating.

H. Treatment of Existing Cracks and All Non-Structural Joints
   1. Identify all the existing cracks and joints and apply a thin layer of the flexible cementitious coating approximately 4 ½” wide and 19 mils thick by trowel or brush.
   2. Embed the non-woven reinforcing fabric over the entire area of this coating and work in using trowel.
   3. Ensure this coating application totally covers the reinforcing fabric.
   4. Let dry sufficiently and apply an additional coat of this flexible cementitious coating to build up to a total thickness of 38 mils over the entire area.

I. Treatment of Inside Corners
   1. Install a 2” x 2” cove over the inside corners using polymer-modified structural repair mortar.
   2. Apply a thin layer of flexible cementitious coating approximately 10" wide and 31 mils by trowel or brush.
   3. Embed the woven reinforcing fabric over the entire area of this coating and work in using trowel.
   4. Ensure this coating application totally covers the reinforcing fabric.
   5. Apply an additional coat of this flexible cementitious coating to build up a total thickness of 63 mils over the entire area.

J. Treatment of Protruding Elements
   1. Apply two coats of flexible cementitious coating at a thickness of 63 mils to both the concrete surface and protruding element.

2. Form a 2” x 2” minimum cove using polymer-modified structural repair mortar in the corner.
3. Allow polymer-modified structural repair mortar to cure.

3.03 MIXING

A. Mix the content of the bag, component A, with the liquid component B.

B. Use a heavy-duty drill (400 - 600 RPM) with a helix screw or paddle mixer to achieve thorough mixing.

C. Pour approximately 80% of the liquid component B into the mixing container (mixer) and gradually add the dry component A into the liquid and mix until a smooth and lump-free mix is obtained.

D. Add the remaining liquid as required for a given application consistency.

E. At high ambient temperatures, and depending on application, one to two cups of water can be added if required.

3.04 APPLICATION

A. Application
1. Brush or spray apply the first coat of cementitious coating to a thickness of 1/32”.
2. If spraying, brush the first coat to eliminate any pinholes.
3. Apply the second coat after approximately 15 - 30 minutes at the same thickness as the first coat (1/32”), giving a finish thickness of 1/16”.
4. Brush the second coat to eliminate pinholes.
5. Protect against surface water evaporation.

B. Finishing
1. To obtain a smooth surface, if required, finish the surface using a steel trowel.

C. Curing
1. Air-dry cure flexible cementitious coating for 72 hours at 68^{o} F and 70 – 80% RH prior to filling with water.
2. Allow for longer curing/drying time will be required with cooler temperatures and a higher relative humidity.

3.05 SITE CLEANUP

A. Remove all excess and waste materials from the jobsite in accordance with contract provisions.

B. Ensure all surrounding areas where the material has been applied and is free of debris.

END OF SECTION

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SECTION 07 21 00

THERMAL INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Extruded polystyrene foam-plastic board insulation.

1.02 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Extruded polystyrene foam-plastic 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.
   1. Sign, date, and post the certification in a conspicuous location on Project site.

B. Product test reports.
   1. Documentation of tests performed by a qualified testing agency

C. Research reports.
   1. For foam-plastic insulation, from ICC-ES

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. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

D. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches and wider in width.

E. Thermal-Resistance Value (R-Value): R-value as indicated on Drawings in accordance with ASTM C518.

2.02 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD INSULATION

A. Extruded Polystyrene Board Insulation, Type VI: ASTM C578, Type VI, 40-psi minimum compressive strength.

2.03 ACCESSORIES

A. Insulation for Miscellaneous Voids:
   1. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.

B. Insulation Anchors, Spindles, and Standoffs: As recommended by manufacturer.

C. Adhesive for Bonding Insulation: Product compatible with insulation and air and water barrier materials, and with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

PART 3 EXECUTION

3.01 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.

3.02 INSTALLATION OF CAVITY-WALL INSULATION

A. Foam-Plastic Board Insulation: Install pads of adhesive spaced approximately 24 inches o.c. both ways on inside face and as recommended by manufacturer.
   1. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions, and with faces flush.
   2. Press units firmly against inside substrates.
   3. Supplement adhesive attachment of insulation by securing boards with two-piece wall ties designed for this purpose and specified in Section 04 20 00 "Unit Masonry."

END OF SECTION

SECTION 07 24 13

POLYMER-BASED EXTERIOR INSULATION AND FINISH SYSTEM (EIFS)

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. EIFS-clad barrier-wall assemblies that are field applied over substrate.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data: For each EIFS component, trim, and accessory.

B. Samples: For each exposed product and for each color and texture specified.

1.04 INFORMATIONAL SUBMITTALS

A. Manufacturer certificates.

B. Product certificates.

C. Product test reports.

D. Field quality-control reports.

E. Sample warranty.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An installer who is certified in writing by AWCI International as qualified to install Class PB EIFS using trained workers.

1.07 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of EIFS that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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. Dryvit Systems, Inc.
   2. Parex USA, Inc.
   3. Sto Corp.
   4. PERFORMANCE REQUIREMENTS

B. EIFS Performance: Comply with ASTM E2568 and with the following:
   1. Weathertightness: Resistant to water penetration from exterior.
   2. Impact Performance: ASTM E2568, High impact resistance.

2.02 EIFS MATERIALS

A. Flexible-Membrane Flashing: Cold-applied, self-adhering, self-healing, rubberized-asphalt and polyethylene-film composite sheet or tape and primer; EIFS manufacturer's standard or product recommended in writing by EIFS manufacturer.

B. Insulation Adhesive: EIFS manufacturer's standard formulation designed for indicated use; compatible with substrate.
   1. Thermal-Resistance Value (R-Value): R-value as indicated on Drawings in accordance with ASTM C518.

C. Molded, (Expanded) Rigid Cellular Polystyrene Board Insulation: Comply with ASTM E2430/E2430M.

D. Reinforcing Mesh: Balanced, alkali-resistant, open-weave, glass-fiber mesh treated for compatibility with other EIFS materials, made from continuous multi-end strands with retained mesh tensile strength of not less than 120 lbf/in. in accordance with ASTM E2098/E2098M.
   1. Reinforcing Mesh for EIFS, General: Not less than weight required to comply with impact-performance level specified in "Performance Requirements" Article.

E. Base Coat: EIFS manufacturer's standard mixture.

F. Primer: EIFS manufacturer's standard factory-mixed, elastomeric-polymer primer for preparing base-coat surface for application of finish coat.

G. Finish Coat: EIFS manufacturer's standard acrylic-based coating.
   1. Colors: As selected by Engineer from manufacturer's full range.
   2. Textures: As selected by Engineer from manufacturer's full range.

H. Trim Accessories: Type as designated or required to suit conditions indicated and to comply with EIFS manufacturer's written instructions; manufactured from UV-stabilized PVC; and complying with ASTM D1784 and ASTM C1063.

PART 3 EXECUTION

3.01 EIFS INSTALLATION

A. Comply with ASTM C1397, ASTM E2511, and EIFS manufacturer's written instructions for installation of EIFS as applicable to each type of substrate.

B. Flexible-Membrane Flashing: Apply and lap to shed water; seal at openings, penetrations, and terminations. Prime substrates with flashing primer if required and install flashing.

C. Trim: Apply trim accessories at perimeter of EIFS, at expansion joints, and elsewhere as indicated. Coordinate with installation of insulation.

D. Board Insulation: Adhesively attach insulation to substrate in compliance with ASTM C1397.

1. Rasp or sand flush entire surface of insulation to remove irregularities projecting more than 1/16 inch from surface of insulation and to remove yellowed areas due to sun exposure; do not create depressions deeper than 1/16 inch. Prevent airborne dispersal and immediately collect insulation raspings and/or sandings.
2. Coordinate installation of flashing and insulation to produce wall assembly that does not allow water to penetrate behind flashing and EIFS lamina.

E. Expansion Joints: Install at locations indicated and where required by EIFS manufacturer.

F. Base Coat: Apply full coverage to exposed insulation with not less than 1/16-inch dry-coat thickness.

G. Reinforcing Mesh: Embed reinforcing mesh in wet base coat to produce wrinkle-free installation with mesh continuous at corners, overlapped not less than 2-1/2 inches or otherwise treated at joints to comply with ASTM C1397. Do not lap reinforcing mesh within 8 inches of corners. Completely embed mesh, applying additional base-coat material if necessary, so reinforcing-mesh color and pattern are invisible.

H. Double-Layer Reinforcing-Mesh Application: Where indicated or required, apply second base coat and second layer of reinforcing mesh, overlapped not less than 2-1/2 inches or otherwise treated at joints to comply with ASTM C1397 in same manner as first application. Do not apply until first base coat has cured.

I. Additional Reinforcing Mesh: Apply strip-reinforcing mesh around openings, extending 4 inches beyond perimeter. Apply additional 9-by-12-inch strip-reinforcing mesh diagonally at corners of openings (re-entrant corners). Apply 8-inch-wide, strip-reinforcing mesh at both inside and outside corners unless base layer of mesh is lapped not less than 4 inches on each side of corners.

J. Double Base-Coat Application: Where indicated, apply second base coat in same manner and thickness as first application, except without reinforcing mesh. Do not apply until first base coat has cured.

K. Finish Coat: Apply full-thickness coverage over dry primed base coat, maintaining a wet edge at all times for uniform appearance, to produce a uniform finish of color and texture matching approved sample and free of cold joints, shadow lines, and texture variations.

L. Sealer Coat: Apply over dry finish coat, in number of coats and thickness required by EIFS manufacturer.

END OF SECTION

SECTION 07 27 26

FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Vapor-permeable, fluid-applied air barriers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. 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. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.

1.03 INFORMATIONAL SUBMITTALS

A. Product certificates.
   1. 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.

B. Product test reports.
   1. For each air-barrier assembly, for tests performed by a
   2. qualified testing agency.

C. Field quality-control reports.

1.04 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 according to ABAA's Quality Assurance Program and to employ ABAA-certified installers and supervisors on Project.

B. Mockups: Build mockups to set quality standards for materials and execution.
   1. Build integrated mockups of exterior wall assembly, incorporating backup wall construction, external cladding, window, storefront, door frame and sill, insulation, ties and other penetrations, and flashing to demonstrate surface preparation, crack and joint treatment, application of air barriers, and sealing of gaps, terminations, and penetrations of air-barrier assembly.
      a. Coordinate construction of mockups to permit inspection and testing of air barrier before external insulation and cladding are installed.
      b. Include junction with roofing membrane and foundation wall intersection.

PART 2 PRODUCTS

2.01 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, 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., 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. pressure difference; ASTM E2178.

D. Ultimate Elongation: Minimum 500 percent; ASTM D412, Die C.

E. Adhesion to Substrate: Minimum 30 lbf/sq. in. 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 30 days in accordance with manufacturer's written instructions.

2.02 HIGH-BUILD AIR BARRIERS, VAPOR PERMEABLE

A. High-Build, Vapor-Permeable Air Barrier Synthetic Polymer Type: Synthetic polymer membrane with an installed dry film thickness, according to manufacturer's written instructions, of 35 mils or thicker over smooth, void-free substrates.
   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 Industrial Adhesives and Tapes Division.
      b. Carlisle Coatings & Waterproofing Inc.
      c. DuPont de Nemours, Inc.

d. GE Construction Sealants; Momentive Performance Materials Inc.
e. Hohmann & Barnard, Inc.
f. Sto Corp.
g. W. R. Meadows, Inc.
h. Vapor Permeance: Minimum 5 perms; ASTM E96/E96M, Procedure B, Water Method.

2.03 ACCESSORY MATERIALS

A. Requirement: 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.

PART 3 EXECUTION

3.01 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 fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching material.

D. Remove excess mortar from masonry ties, shelf angles, and other obstructions.

E. 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.

F. Bridge 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.

3.02 INSTALLATION

A. Install 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 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.

B. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.

C. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition strip so that a minimum of 3 inches of coverage is achieved over each substrate. Maintain 3 inches of full contact over firm bearing to perimeter frames.

D. Repair punctures, voids, and deficient lapped seams in strips and transition strips. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches beyond repaired areas in strip direction.

E. High-Build Air Barriers: Apply continuous unbroken air-barrier material to substrates according to the following thickness. Apply air-barrier material in full contact around protrusions such as masonry ties.
1. Vapor-Permeable, High-Build Air Barrier: Total dry film thickness as recommended in writing by manufacturer to comply with performance requirements, but not less than 35 mils, applied in one or more equal coats.

F. Do not cover air barrier until it has been tested and inspected by testing agency.

G. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.03 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests: As determined by testing agency from among the following tests:
1. Air-barrier dry film thickness.
2. Air-Leakage-Location Testing: Air-barrier assemblies will be tested for evidence of air leakage in accordance with ASTM E1186, chamber pressurization or depressurization with smoke tracers.
3. Air-Leakage-Volume Testing: Air-barrier assemblies will be tested for air-leakage rate in accordance with ASTM E2357.
4. Adhesion Testing: Air-barrier assemblies will be tested for required adhesion to substrate in accordance with ASTM D4541 for each 600 sq. ft. of installed air barrier or part thereof.

C. 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.

D. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.

E. Prepare test and inspection reports.

3.04 CLEANING AND PROTECTION

A. Protect air-barrier system from damage during application and remainder of construction period, in accordance with manufacturer's written instructions.

B. Remove masking materials after installation.

END OF SECTION

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SECTION 07 41 13

STANDING-SEAM METAL ROOF PANELS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Standing-seam metal roof panels.
   2. Vapor retarder.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Meet with Owner, Architect, 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 roof accessories and roof-mounted equipment.
   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 structural loading limitations of deck purlins and rafters during and after roofing.
   6. Review flashings, special details, drainage, penetrations, equipment curbs, and condition of other construction that affect metal panels.
   7. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
   8. Review temporary protection requirements for metal panel systems during and after installation.
   9. Review procedures for repair of metal panels damaged after installation.
   10. 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
   2. For recycled content, indicating post-consumer and pre-consumer recycled content and cost.

B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.

C. Samples: For each type of metal panel indicated, minimum 2” x 2”

1.04 INFORMATIONAL SUBMITTALS

A. Product test reports.
   1. for tests performed by a qualified testing agency.

B. Warranties: Sample of special warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.

1.07 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. Warranty Period: Two 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. Finish Warranty Period: 20 years from date of Substantial Completion.

C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, within specified warranty period.
   1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Energy Performance:
   1. Provide roof panels that are listed on the EPA/DOE's ENERGY STAR "Roof Product List" for steep-slope roof products.

2. Provide roof panels according to one of the following when tested according to CRRC-1:
    a. Three-year, aged solar reflectance of not less than 0.55 and emissivity of not less than 0.75.
    b. Three-year, aged Solar Reflectance Index of not less than 64 when calculated according to ASTM E1980.

B. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:
    1. Wind Loads: As indicated on Drawings.
    2. Deflection Limits: For wind loads, no greater than 1/240 of the span.

C. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E1680 at the following test-pressure difference:
    1. Test-Pressure Difference: 6.24 lbf/sq. ft.

D. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E1646 at the following test-pressure difference:
    1. Test-Pressure Difference: 6.24 lbf/sq. ft.

E. Hydrostatic-Head Resistance: No water penetration when tested according to ASTM E2140.

F. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.
    1. Hail Resistance: SH.

G. 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, ambient; 180 deg F, material surfaces.

2.02 STANDING-SEAM METAL ROOF PANELS

A. Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
    1. Steel Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E1514.

B. Vertical-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and a flat pan between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels, engaging opposite edge of adjacent panels, and mechanically seaming panels together.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Berridge Manufacturing Company; Berridge Zee-Lock Double Lock or a comparable product by one of the following:
      a. AEP Span a brand of ASC Profiles LLC, a part of BlueScope.
      b. ATAS International, Inc.
      c. Fabral; a brand of OmniMax International.
      d. MBCI; Cornerstone Building Brands.
      e. Metal Sales Manufacturing Corporation.
      f. PAC-CLAD; Petersen Aluminum Corporation; a Carlisle company.
      g. Ultra Seam, Inc.
      h. Or approved equal.
   2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A792/A792M, Class AZ50 coating designation; structural quality. Pre-painted by the coil-coating process to comply with ASTM A755/A755M.
      a. Nominal Thickness: 0.028 inch.
      b. Exterior Finish: Two-coat fluoropolymer.
      c. Color: As selected by Engineer from manufacturer's full range.
   3. Clips: One-piece fixed.
   4. Material:
      a. 0.028-inch- nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
   5. Joint Type: Double folded.
   6. Panel Coverage: 16 inches.
   7. Panel Height: 2.0 inches.

2.03 VAPOR RETARDER

A. Butyl Rubber Sheet Vapor Retarder, Self-Adhering: Polyethylene film laminated to layer of butyl rubber adhesive, minimum 30-mil total thickness; maximum permeance rating of 0.1 perm; cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

2.04 UNDERLAYMENT MATERIALS

A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 40 mils thick, consisting of slip-resistant, polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive, with release-paper backing. Provide primer when recommended by underlayment manufacturer.
   1. Thermal Stability: Stable after testing at 240 deg F; ASTM D1970.
   2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D1970.

3. Basis-of-Design Product: Subject to compliance with requirements, provide Grace Ice & Watershield HT or a comparable product by one of the following:
   a. Tamko.
   b. Mid-States Asphalt.
   c. Soprema.
   d. MFM.
   e. Polyglass.
   f. Or approved equal.

B. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

2.05 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Sub-framing and Furring: ASTM C645; cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 hot-dip galvanized coating designation or ASTM A792/A792M, Class AZ50 coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
   1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.
   2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
   3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick, flexible closure strips; cut or pre-molded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

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, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

D. Gutters and Downspouts: Formed from same material as roof panels according to current edition of SMACNA's "Architectural Sheet Metal Manual." Finish to match metal roof panels, roof fascia and rake trim.

E. Panel Fasteners: Self-tapping screws designed to withstand design loads.

F. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
   1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch wide and 1/8 inch thick.
   2. Joint Sealant: ASTM C920; as recommended in writing by metal panel manufacturer.
   3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.06 FABRICATION

A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.

C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.07 FINISHES

A. Panels and Accessories:
   1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat.
   2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 EXECUTION

3.01 PREPARATION

A. Miscellaneous Supports: Install sub-framing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

3.02 INSTALLATION OF VAPOR RETARDER

A. Loosely lay vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 and 6 inches, respectively.

3.03 INSTALLATION OF UNDERLAYMENT

A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.
   1. Apply over the entire roof surface.

B. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels.

C. Flashings: Install flashings to cover underlayment to comply with requirements specified in Section 07 62 00 "Sheet Metal Flashing and Trim."

3.04 INSTALLATION OF STANDING-SEAM METAL ROOF PANELS

A. Standing-Seam Metal Roof Panel Installation: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.
   1. Install clips to supports with self-tapping fasteners.
   2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
   3. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.
   4. Watertight Installation:
      a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels, using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.
      b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
      c. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.

B. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.

C. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

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.

END OF SECTION

SECTION 07-53-23

ETHYLENE-PROPYLENE-DIENE-MONOMER (EPDM) ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Adhered ethylene-propylene-diene-terpolymer (EPDM) roofing system.
   2. Accessory roofing materials.
   3. Roof insulation.
   4. Insulation accessories and cover board.

1.02 ACTION SUBMITTALS

A. Shop Drawings: Include roof plans, sections, details, and attachments to other work, including the following:
   1. Layout and thickness if 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.

B. Wind Uplift Resistance Submittal: For roofing system, indicating compliance with wind uplift performance requirements in the Drawings

1.03 INFORMATIONAL SUBMITTALS

A. 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.

B. Product Test Reports: For components of roof membrane and insulation, for tests performed by a qualified testing agency, indicating compliance with specified requirements.

C. Research reports.

D. Field Test Reports:
   1. Concrete internal relative humidity test reports.
   2. Fastener-pullout test results and manufacturer's revised requirements for fastener patterns.

E. Field quality-control reports.
   1. Provide field quality control reports recommended by manufacturer.

F. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Certified statement from existing roof membrane manufacturer stating that existing roof warranty has not been affected by Work performed under this Section.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installers: 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.

1.06 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. Warranty Period: 10 years from Date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Accelerated Weathering: Roof membrane to withstand 2000 hours of exposure when tested in accordance with ASTM G152, ASTM G154, or ASTM G155.

B. 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.

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:

2.02 ETHYLENE-PROPYLENE-DIENE-TERPOLYMER (EPDM) ROOFING

A. EPDM Sheet: ASTM D4637/D4637M, Type I, nonreinforced, EPDM sheet.
   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. Carlisle Syntec Systems.
      b. GenFlex Roofing Systems.
      c. Johns Manville; a Berkshire Hathaway company.
      d. Versico Roofing Systems; Carlisle Construction Materials.
      e. Or approved equal.
      f.
   2. Thickness: 60 mils, nominal.
   3. Exposed Face Color: Black.

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-thick EPDM, partially cured or cured, according to application.

C. Protection Sheet: Epichlorohydrin or neoprene nonreinforced flexible sheet, 55 to 60 mils thick, recommended by EPDM manufacturer for resistance to hydrocarbons, non-aromatic solvents, grease, and oil.

D. Slip Sheet: ASTM D2178/D2178M, Type IV; glass fiber; asphalt-impregnated felt.

E. Prefabricated Pipe Flashings: As recommended by roof membrane manufacturer.

F. Bonding Adhesive: Manufacturer's standard, water based.

G. Seaming Material: Manufacturer's standard, synthetic-rubber polymer primer and 3-inch-wide minimum, butyl splice tape with release film.

H. Lap Sealant: Manufacturer's standard, single-component sealant.

I. Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.

J. Metal Termination Bars: Manufacturer's standard, predrilled stainless steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.

K. 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.

L. 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.

2.04 ROOF INSULATION

A. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 2 coated glass-fiber facer on both major surfaces.
   1. Size: 48 by 96 inches.
   2. Thickness:
      a. Base Layer: 3 inches.
      b. Upper Layer: 3 inches.

B. Tapered Insulation: Provide factory-tapered insulation boards.
   1. Material: Match roof insulation.
   2. Minimum Thickness: 1/4 inch.
   3. Slope:
      a. Roof Field: 1/4 inch per foot unless otherwise indicated on Drawings.

2.05 INSULATION ACCESSORIES AND COVER BOARD

A. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer as follows:
   1. Modified asphaltic, asbestos-free, cold-applied adhesive.
   2. Bead-applied, low-rise, one-component or multicomponent urethane adhesive.
   3. Full-spread, spray-applied, low-rise, two-component urethane adhesive.

B. Glass-Mat Gypsum Cover Board: ASTM C1177/C1177M, water-resistant gypsum board.
   1. Thickness: 1/2 inch.
   2. Surface Finish: Fiberglass facer.

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 minimum concrete drying period recommended by roofing system manufacturer has passed.
   2. Verify that concrete substrate is visibly dry and free of moisture, and that minimum concrete internal relative humidity is not more than 75 percent, or as recommended by roofing system manufacturer when tested in accordance with ASTM F2170.
      a. Test Frequency: One test probe per each 1000 sq. ft., or portion thereof, of roof deck, with not less than three test probes.
      b. Submit test reports within 24 hours of performing tests.

3. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.

3.02 PREPARATION

A. 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.

B. Install sound-absorbing insulation strips in accordance with acoustical roof deck manufacturer's written instructions.

3.03 INSTALLATION OF ROOFING, GENERAL

A. Install roofing system in accordance with roofing system manufacturer's written instructions, 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. Install roof membrane and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition.

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 Concrete Decks:
   1. Install base layer of insulation with joints staggered not less than 24 inches in adjacent rows.
      a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
      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 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.
         1) Trim insulation so that water flow is unrestricted.
      e. Fill gaps exceeding 1/4 inch with insulation.

f. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
g. Loosely lay base layer of insulation units over substrate.
h. Adhere base layer of insulation to concrete roof deck in accordance with FM Approvals' RoofNav assembly requirements and FM Global Property Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification, as follows:
    1) Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. and allow primer to dry.
    2) Set insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F of equiviscous temperature.
    3) Set insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
    4) Set insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

2. Install upper layers of insulation and tapered insulation with joints of each layer offset not less than 12 inches from previous layer of insulation.
    a. Staggered end joints within each layer not less than 24 inches in adjacent rows.
    b. Install with long joints continuous and with end joints staggered not less than 12 inches in adjacent rows.
    c. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
    d. Make joints between adjacent insulation boards not more than 1/4 inch in width.
    e. Fill gaps exceeding 1/4 inch with insulation.
    f. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
    g. Loosely lay each layer of insulation units over substrate.
    h. Adhere each layer of insulation to substrate using adhesive in accordance with FM Approvals' RoofNav assembly requirements and FM Global Property Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification, as follows:
        1) Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F of equiviscous temperature.
        2) Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
        3) Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

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 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 assembly requirements and FM Global Property Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification, as follows:
    a. Set cover board in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F of equiviscous temperature.
    b. Set cover board in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
    c. Set cover board in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

B. Install slip sheet over cover board and immediately beneath roofing.

3.06 ADHERED ROOFING INSTALLATION

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 and Owner's testing and inspection agency.

D. Accurately align roof membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

E. Bonding Adhesive: Apply to substrate and underside of roof membrane at rate required by manufacturer and allow to partially dry before installing roof membrane. Do not apply to splice area of roof membrane.

F. In addition to adhering, mechanically fasten roof membrane securely at terminations, penetrations, and perimeters.

G. Apply roof membrane with side laps shingled with slope of roof deck where possible.

H. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement.
1. Firmly roll side and end laps of overlapping roof membrane to ensure a watertight seam installation.
2. Apply lap sealant and seal exposed edges of roofing terminations.
3. Apply a continuous bead of in-seam sealant before closing splice if required by roofing system manufacturer.

I. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape.
1. Firmly roll side and end laps of overlapping roof membrane to ensure a watertight seam installation.
2. Apply lap sealant and seal exposed edges of roofing terminations.

J. Spread sealant or mastic bed over deck-drain flange at roof drains, and securely seal roof membrane in place with clamping ring.

K. Adhere protection sheet over roof membrane at locations indicated.

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 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to inspect substrate conditions, surface preparation, roof membrane application, flashings, protection, and drainage components, and to furnish reports to Architect.

B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion, in presence of Architect, and to prepare inspection report.

C. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.

3.09 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

SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Formed roof-drainage sheet metal fabrications.
   2. Formed steep-slope roof sheet metal fabrications.

1.02 ACTION SUBMITTALS

A. Product Data: For each of the following
   1. Elastomeric sealant.
   2. Butyl sealant.

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 edge conditions, including eaves, ridges, valleys, rakes, crickets, flashings, and counter-flashings.
   10. Include details of special conditions.
   11. Include details of connections to adjoining work.

C. Samples: For each exposed product and for each color and texture specified, 12 inches long by actual width.

1.03 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Special warranty.

1.05 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.

1.06 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows 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 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. 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 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, 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: 120 deg F, ambient; 180 deg F, 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. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet in accordance with ASTM A653/A653M, G90 coating designation; pre-painted by coil-coating process to comply with ASTM A755/A755M.
   1.
   2. Surface: Smooth, flat.

3. Exposed Coil-Coated Finish:
    a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish 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.
4. Color: As selected by Engineer from manufacturer's full range.
5. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil.

2.03 MISCELLANEOUS MATERIALS

A. Provide materials and types of fasteners, 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 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.
    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 Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329.

C. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, non-sag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

D. Elastomeric Sealant: ASTM C920, elastomeric polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

E. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

F. Bituminous Coating: Cold-applied asphalt emulsion in accordance with ASTM D1187/D1187M.

G. Asphalt Roofing Cement: ASTM D4586, asbestos free, of consistency required for application.

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 on slope and location lines indicated on Drawings and within 1/8-inch 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 deep, filled with butyl sealant concealed within joints.
   2. Use lapped expansion joints only where indicated on Drawings.

D. Sealant Joints: Where movable, non-expansion-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. Seams:
   1. Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.

2.05 ROOF-DRAINAGE SHEET METAL FABRICATIONS

A. Hanging Gutters:
   1. Fabricate to cross section required, complete with end pieces, outlet tubes, and other accessories as required.
   2. Fabricate in minimum 96-inch-long sections.

3. Furnish flat-stock gutter brackets and flat-stock gutter spacers and straps fabricated from same metal as gutters, of size recommended by cited sheet metal standard, but with thickness not less than twice the gutter thickness.
4. Fabricate expansion joints, expansion-joint covers, and gutter accessories from same metal as gutters.
5. Gutters with Girth up to 15 Inches: Fabricate from the following materials:
    a. Galvanized Steel: 0.028 inch thick.

B. Downspouts: Fabricate rectangular downspouts to dimensions indicated on Drawings, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors. Shop fabricate elbows.
1. Fabricate from the following materials:
    a. Galvanized Steel: 0.028 inch thick.

2.06 STEEP-SLOPE ROOF SHEET METAL FABRICATIONS

A. Drip Edges: Fabricate from the following materials:
1. Galvanized Steel: 0.028 inch thick.

B. Eave, Rake Flashing: Fabricate from the following materials:
1. Galvanized Steel: 0.028 inch thick.

PART 3 EXECUTION

3.01 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, 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 sealant.
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 o.c.
6. Space individual cleats not more than 12 inches 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.

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 sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
   2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim.
   1. Space movement joints at maximum of 10 feet with no joints within 24 inches of corner or intersection.
   2. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant concealed within joints.
   3. Use lapped expansion joints only where indicated on Drawings.

D. Fasteners: Use fastener sizes that penetrate wood blocking or sheathing not less than 1-1/4 inches for nails and not less than 3/4 inch for wood screws.

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.
   1. Use sealant-filled joints unless otherwise indicated.
      a. Embed hooked flanges of joint members not less than 1 inch into sealant.
      b. Form joints to completely conceal sealant.
      c. When ambient temperature at time of installation is between 40 and 70 deg F, set joint members for 50 percent movement each way.
      d. Adjust setting proportionately for installation at higher ambient temperatures.
         1) Do not install sealant-type joints at temperatures below 40 deg F.
   2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

3.02 INSTALLATION OF ROOF-DRAINAGE SYSTEM

A. Install sheet metal roof-drainage items to produce complete roof-drainage system in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.

B. Hanging Gutters:
   1. Join sections with joints sealed with sealant.
   2. Provide for thermal expansion.
   3. Attach gutters at eave or fascia to firmly anchor them in position.
   4. Provide end closures and seal watertight with sealant.
   5. Slope to downspouts.

6. Install gutter with expansion joints at locations indicated on Drawings, but not exceeding, 50 feet apart. Install expansion-joint caps.

C. Downspouts:
   1. Join sections with 1-1/2-inch telescoping joints.
   2. Provide hangers with fasteners designed to hold downspouts securely to walls.
   3. Locate hangers at top and bottom and at approximately 60 inches o.c.
   4. Provide elbows at base of downspout to direct water away from building.

3.03 INSTALLATION OF ROOF FLASHINGS

A. Install sheet metal flashing and trim to comply with performance requirements and cited sheet metal standard.
   1. Provide concealed fasteners where possible, and set units true to line, levels, and slopes.
   2. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches over base flashing. Install stainless steel draw band and tighten.

C. Counterflashing: Coordinate installation of counterflashing with installation of base flashing.
   1. Insert counterflashing in reglets or receivers and fit tightly to base flashing.
   2. Extend counterflashing 4 inches over base flashing.
   3. Lap counterflashing joints minimum of 4 inches.

D. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.04 INSTALLATION TOLERANCES

A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.05 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.

3.06 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. 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 72 53

SNOW GUARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

B. Rail-type, seam-mounted snow guards.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include roof plans showing layouts and attachment details of snow guards.

C. Include details of rail-type snow guards.

D. Delegated-Design Submittal: For snow guards, include analysis reports signed and sealed by the qualified professional engineer responsible for their preparation.

E. Include calculation of number and location of snow guards.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer's experience with providing delegated design engineering services of the kind indicated, including documentation that the engineer is licensed in the jurisdiction in which the Project is located.

B. Product Test Reports: For each type of snow guard, for tests performed by a qualified testing agency, indicating load at failure of attachment to roof system identical to roof system used on this Project.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 45 00 “Contractor Quality Control,” to design snow guards, including attachment to roofing material and roof deck, applicable for attachment method, based on the following:

B. Roof snow load.

C. Snow drifting

D. Roof slope.

E. Roof type.

F. Roof dimensions.

G. Roofing substrate type and thickness.

H. Snow guard type.

I. Snow guard fastening method and strength.

J. Snow guard spacing.

K. Coefficient of Friction Between Snow and Roof Surface: 0.

L. Factor of Safety: 2.

M. Performance Requirements: Provide snow guards that withstand exposure to weather and resist thermally induced movement without failure, rattling, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

N. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

O. Structural Performance: Snow guards shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.

P. Snow Loads: Refer to Section 01 73 24.

2.02 RAIL-TYPE SNOW GUARDS

A. Rail-Type, Seam-Mounted Snow Guards:

B. Basis-of-Design Product: Subject to compliance with requirements, provide S-5! Metal Roof Innovations, Ltd.; SnoRail/SnoFence or a comparable product by one of the following:
   a. Alpine SnowGuards.
   b. IceBlox Inc.
   c. LMCurbs.
   d. Rocky Mountain Snow Guards, Inc.
   e. TRA Snow and Sun, Inc.
   f. Or approved equal.

C. Description: Snow guard rails fabricated from metal pipes, bars, or extrusions, anchored to brackets and equipped with two rails.

D. Brackets and Baseplates: ASTM B209 aluminum, clear anodized.

E. Bars: ASTM B221 aluminum; mill finish.
   a. Profile: Round.

F. Seam clamps: ASTM B221 aluminum extrusion or ASTM B85/B85M aluminum casting with stainless steel set screws incorporating round nonpenetrating point; designed for use with applicable roofing system to which clamp is attached.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install snow guards according to manufacturer's written instructions.

B. Space rows as recommended by manufacturer.

C. Attachment for Standing-Seam Metal Roofing:

D. Do not use fasteners that will penetrate metal roofing or fastening methods that void metal roofing finish warranty.

E. Rail-Type, Seam-Mounted Snow Guards:
   a. Install brackets to vertical ribs in straight rows.
   b. Secure with stainless steel set screws, incorporating round nonpenetrating point, on same side of standing seam.
   c. Torque set screw according to manufacturer's instructions.
   d. Install cross members to brackets.

END OF SECTION

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SECTION 07 91 26

JOINT FILLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies preformed joint fillers.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D994	Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ASTM D1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

PART 2 PRODUCTS

2.01 PREFORMED ASPHALT FIBERBOARD

A. Preformed asphalt fiberboard joint filler shall be in accordance with ASTM D994 and shall be 1/2 inch thick unless otherwise specified.

2.02 PREFORMED RESIN-BONDED CORK

A. Preformed resin-bonded cork joint filler shall be in accordance with ASTM D1752, Type II. Cork joint filler thickness shall match the specified joint width.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's recommendations for handling and installation of the material.

PART 3 EXECUTION

3.01 GENERAL

A. Preformed joint fillers shall be placed into position before the concrete is poured. Where it is necessary for the filler to be fixed to existing concrete or other building materials, a suitable adhesive recommended by the filler manufacturer shall be used. Filler surfaces shall be clean and dry prior to the placement of the concrete.

3.02 PREFORMED ASPHALT FIBERBOARD

A. Preformed asphalt fiberboard joint fillers shall be used for expansion joints in concrete sidewalks, curbs, and roadways.

3.03 PREFORMED RESIN-BONDED CORK

A. Preformed resin-bonded cork joint filler shall be used for expansion joints in concrete structures. The expansion joint shall be sealed with backer rod and sealant as specified in Section 07 92 00.

END OF SECTION

SECTION 07 92 00

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Silicone joint sealants.
   2. Urethane joint sealants.
   3. Latex joint sealants.

1.02 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product.

B. Samples: For each kind and color of joint sealant required.

C. 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. Product test reports.

B. Preconstruction laboratory test reports.

C. Preconstruction field-adhesion-test reports.

D. Field-adhesion-test reports.

E. Sample warranties.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C1021 to conduct the testing indicated.

1.05 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.

PART 2 PRODUCTS

2.01 JOINT SEALANTS, GENERAL

A. Colors of Exposed Joint Sealants: As selected by Engineer from manufacturer's full range.

2.02 NONSTAINING SILICONE JOINT SEALANTS

A. Nonstaining Joint Sealants: No staining of substrates when tested according to ASTM C1248.

B. Silicone, Nonstaining, S, NS, 50, NT: Nonstaining, single-component, non-sag, 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.

2.03 URETHANE JOINT SEALANTS

A. Urethane, S, NS, 25, NT: Single-component, non-sag, nontraffic-use, plus 25 percent and minus 25 percent movement capability, urethane joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

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.

C. Urethane, M, P, 50, T, NT: Multicomponent, pourable, plus 50 percent and minus 50 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C920, Type M, Grade P, Class 50, Uses T and NT.

2.04 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, Acid Curing, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

C. Acrylic Latex: Acrylic latex or siliconized acrylic latex, ASTM C834, Type OP, Grade NF.

2.05 JOINT-SEALANT BACKING

A. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

B. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer.

2.06 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.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 EXECUTION

3.01 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 laitance and form-release agents from concrete.
   2. 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.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces.

3.02 INSTALLATION OF JOINT SEALANTS

A. General: Comply with ASTM C1193 and joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Install sealant backings of kind 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.

C. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

D. 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.

E. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants to form smooth, uniform beads of configuration indicated. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
   1. Provide concave joint profile per Figure 8A in ASTM C1193 unless otherwise indicated.

3.03 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.
      b. Other joints as indicated on Drawings.
   2. Joint Sealant: Urethane, M, P, 50, T, NT.
   3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

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. Other joints as indicated on Drawings.
   2. Joint Sealant: Silicone, nonstaining, S, NS, 50, NT.
   3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

C. Joint-Sealant Application: Interior joints in horizontal traffic surfaces.
   1. Joint Locations:
      a. Isolation joints in cast-in-place concrete slabs.
      b. Other joints as indicated on Drawings.
   2. Joint Sealant: Urethane, S, P, 25, T, NT.
   3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

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.
      c. Other joints as indicated on Drawings.
   2. Joint Sealant: Urethane, S, NS, 25, NT.
   3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

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 windows.

c. Other joints as indicated on Drawings.

2. Joint Sealant: Acrylic latex.
3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

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.
      b. Other joints as indicated on Drawings.
   2. Joint Sealant: Silicone, mildew resistant, acid curing, S, NS, 25, NT.
   3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

G. Joint-Sealant Application: Concealed mastics.
   1. Joint Locations:
      a. Aluminum thresholds.
      b. Sill plates.
      c. Other joints as indicated on Drawings.
   2. Joint Sealant: Butyl-rubber based.
   3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

END OF SECTION

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SECTION 08 11 13

HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Interior standard steel doors and frames.
   2. Exterior standard steel doors and frames.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Product Schedule: For hollow-metal 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.

1.03 INFORMATIONAL SUBMITTALS

A. Product test reports.

B. Field quality control reports.

1.04 CLOSEOUT SUBMITTALS

A. 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. 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.

B. Egress Door Inspector Qualifications: Inspector for field quality control inspections of egress door assemblies is to meet the qualifications set forth in NFPA 101, Section 7.2.1.15.4 and the following:
   1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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. Ceco Door; AADG, Inc.; ASSA ABLOY.
   2. Curries, AADG, Inc.; ASSA ABLOY Group.
   3. Custom Metal Products.
   4. National Custom Hollow Metal Doors & Frames.
   5. North American Door Corp.
   6. Republic Doors and Frames; a Allegion brand.
   7. Rocky Mountain Metals, Inc.
   8. Steelcraft; Allegion plc.
   9. Stiles Custom Metal, Inc.
   10. West Central Manufacturing, Inc.

2.02 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.

B. Thermally Rated Door Assemblies: Provide door assemblies with U-factor of not more than 0.38 deg Btu/F x h x sq. ft. when tested in accordance with ASTM C1363 or ASTM E1423.

2.03 INTERIOR STANDARD STEEL DOORS AND FRAMES

A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 2; ANSI/SDI A250.4, Level B.
   1. Doors:
      a. Type: As indicated in the Door and Frame Schedule.
      b. Thickness: 1-3/4 inches.
      c. Face: Metallic-coated steel sheet, minimum thickness of 0.042 inch.

d. Edge Construction: Model 2, Seamless.
e. Core: Manufacturer's standard.
f. Fire-Rated Core: Manufacturer's standard core for fire-rated doors.

2. Frames:
a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch.
b. Transom Frames: Fabricated from same thickness material as adjacent door frame.
c. Construction: Full profile welded.

2.04 EXTERIOR STANDARD STEEL DOORS AND FRAMES

A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Extra-Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 3; ANSI/SDI A250.4, Level A.
1. Doors:
a. Type: As indicated in the Door and Frame Schedule.
b. Thickness: 1-3/4 inches.
c. Face: Metallic-coated steel sheet, minimum thickness of 0.053 inch, with minimum A60 coating.
d. Edge Construction: Model 2, Seamless.
e. Top Edge Closures: Close top edges of doors with flush closures of same material as face sheets. Seal joints against water penetration.
f. Bottom Edges: Close bottom edges of doors with end closures or channels of same material as face sheets. Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape.
g. Core: Manufacturer's standard.
2. Frames:
a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch, with minimum A60 coating.
b. Construction: Full profile welded.

2.05 FRAME ANCHORS

A. Jamb Anchors:
1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches of frame height above 7 feet.
3. Post installed Expansion Anchor: Minimum 3/8-inch-diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.

B. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.

C. Floor Anchors for Concrete Slabs with Underlayment: Adjustable-type anchors with extension clips, allowing not less than 2-inch height adjustment. Terminate bottom of frames at top of underlayment.

D. Material: ASTM A879/A879M, Commercial Steel (CS), 04Z coating designation; mill phosphatized.
   1. For anchors built into exterior walls, steel sheet complying with ASTM A1008/A1008M or ASTM A1011/A1011M; hot-dip galvanized in accordance with ASTM A153/A153M, Class B.

2.06 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

C. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B.

D. Inserts, Bolts, and Fasteners: Hot-dip galvanized in accordance with ASTM A153/A153M.

E. 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 hollow-metal frames of type indicated.

F. Mineral-Fiber Insulation: ASTM C665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E136 for combustion characteristics.

G. Glazing: Comply with requirements in Section 08 80 00 "Glazing."

2.07 FABRICATION

A. Door Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.

B. Hollow-Metal Frames: 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.
   1. Transom Bar Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by welding, or by rigid mechanical anchors.
   2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.

3. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
    a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
    b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

C. Hardware Preparation: Factory prepared hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping in accordance with ANSI/SDI A250.6, the Door Hardware Schedule, and templates.
    1. Reinforce doors and frames to receive non-templated, mortised, and surface-mounted door hardware.
    2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

D. Glazed Lites: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with mitered-hairline joints.
    1. Provide stops and moldings flush with face of door, and with beveled stops unless otherwise indicated.
    2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
    3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames. Provide loose stops and moldings on inside of hollow-metal doors and frames.
    4. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.
    5. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches o.c. and not more than 2 inches o.c. from each corner.

2.08 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.
    1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

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. Touch up factory-applied finishes where spreaders are removed.

B. Drill and tap doors and frames to receive non-templated, mortised, and surface-mounted door hardware.

3.02 INSTALLATION

A. Hollow-Metal Frames: Comply with ANSI/SDI A250.11.
   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. Touch-up finishes.
      b. Install frames with removable stops located on secure side of opening.
   2. Fire-Rated Openings: Install frames in accordance with NFPA 80.
   3. Floor Anchors: Secure with post-installed expansion anchors.
      a. Floor anchors may be set with power-actuated fasteners instead of post-installed 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 post-installed expansion anchors.
   6. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:
      a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
      b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
      c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
      d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.

B. Hollow-Metal Doors: Fit and adjust hollow-metal doors accurately in frames, within clearances specified below.
   1. Non-Fire-Rated Steel Doors: Comply with ANSI/SDI A250.8.
   2. Fire-Rated Doors: Install doors with clearances in accordance with NFPA 80.

C. Glazing: Comply with installation requirements in Section 08 80 00 "Glazing" and with hollow-metal manufacturer's written instructions.

3.03 FIELD QUALITY CONTROL

A. Inspection Agency: Engage a qualified inspector to perform inspections and to furnish reports to Architect.

B. Inspections:
   1. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.
   2. 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 REPAIR

A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

B. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

C. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION

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SECTION 08 31 20

FLOOR ACCESS DOORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Factory-fabricated single or double leaf aluminum floor access doors and frames with water drainage. Include safety chain, telescoping ladder safety post, and fall protection grating system where indicated.

1.02 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B632	Aluminum-Alloy Rolled Tread Plate
ASTM A240	Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AASHTO	American Association of State Highway and Transportation Officials
OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Statement of experience for both manufacturer and installer.
   5. Fabrication drawings showing layouts, connections to structure, and anchoring details.
   6. Erection and installation drawings showing construction details, reinforcement, anchorage, and installation with relation to the building construction.

7. Drain pipe layout from the drain coupling to the discharge point.

B. Informational Submittals:
   1. Manufacturer's product data showing conformance to the specification.
   2. Structural calculations for the floor access door design provided by the manufacturer and sealed by a registered professional engineer registered in the State of Utah.
   3. Instructions for the storage, handling, installation, and operation.
   4. Manufacturer's warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer: Minimum of 5 years' experience manufacturing similar products.

B. Installer: Minimum of 2 years' experience installing similar products.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in manufacturer's original packaging, stored in a dry, protected, well-vented area. Inspect product upon receipt and report damage to carrier and manufacturer.

1.06 SPECIAL WARRANTY

A. Materials shall be free of defects in material and workmanship for a period of 5 years from the date of purchase. Should a part fail to function in normal use within this period, manufacturer shall furnish a new part at no charge.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following manufacturers are acceptable. The manufacturer's standard product may require modification to conform to specified requirements.
   1. The Bilco Company.
   2. Babcock Davis.
   3. Halliday Products.
   4. East Jordan Iron Works (EJ).
   5. Approved Equivalent.

2.02 PERFORMANCE/DESIGN CRITERIA

A. Door leafs shall be reinforced to support a minimum live load of 300 psf with a maximum deflection of 1/150th of the span. See Floor Access Door Schedule at the end of this section, which indicates loading criteria required at each location.

B. Nominal opening sizes and hinge opening side shall be as noted on the Drawings and in the Floor Access Door Schedule.

2.03 MATERIALS

A. Access doors, single or double leaf: 1/4 inch minimum aluminum with diamond tread pattern; ASTM B632, 6061-T6.

B. Channel frame shall be 1/4 inch minimum extruded aluminum with bent down anchor tabs around the perimeter: ASTM B221, 6061-T6.

C. Hardware: ASTM A240 Type 316 stainless steel throughout.

D. Fasteners:
   1. Bolts: ASTM F593
   2. Nuts: ASTM F594

2.04 COMPONENTS/ FEATURES

A. Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled door leaf operation throughout the entire arc of opening; and to act as a check in retarding downward motion of the cover when closing.

B. Spring tubes shall be constructed of a reinforced nylon 6/6-based engineered composite material. The upper tube shall prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4 inch gusset support plate.

C. Door leafs shall be equipped with a hold-open arm which automatically locks the door in the open position. A removable exterior turn/lift handle with a spring loaded ball detent shall be provided to open the door and the latch release shall be protected by a flush, gasketed, removable screw plug. A stainless steel snap lock with fixed handle shall be mounted on the underside of the door.

D. Provide heavy forged aluminum hinges with 1/4 inch minimum diameter stainless steel pins.
   1. Hinges must operate in such a manner to prevent the door leafs from protruding into the channel frame.
   2. Design hinges specifically for horizontal installation.
   3. Hinges shall be through-bolted to the cover with tamperproof stainless steel lock bolts and through-bolted to the frame with stainless steel bolts and locknuts.

E. A continuous ethylene propylene diene monomer (EPDM) gasket shall be mechanically attached to the aluminum frame to create a barrier around the entire perimeter of the cover and significantly reduce the amount of dirt and debris that may enter the channel frame.

F. A 1.5 inch drain coupling shall be provided.

G. Provide a continuous EPDM odor resistant gasket along the inside edge of the frame where indicated in the Floor Access Door Schedule. This gasket is in addition to the perimeter debris gasket.

H. Provide safety chain made of non-corrosive material that will span across the corners of double leaf access doors when open.

I. Provide telescoping ladder safety posts for easy, safe ladder access through the access door openings.
   1. Material: Stainless steel.
   2. Telescoping post to be permanently mounted to the top two rungs of fixed ladders.
   3. Post must automatically lock in the fully raised position to provide the user with a firm and steady hand-hold.
   4. Post to have release lever that allows the post to be easily lowered to its retracted position.

J. Provide a fall protection grating system where indicated in the Floor Access Door Schedule. Manufacturer shall install the grating system when the door is fabricated.
   1. Design Criteria: Meet OSHA 29 CFR 1910.23 requirements for fall protection.
   2. Grating panel material: Aluminum with powder coat paint finish.
   3. Grating panel color: High visibility OSHA safety yellow or orange.
   4. Grating panel shall lock automatically in the full open position.
   5. Grating panel shall lift open in the opposite direction as the door(s).
   6. Hold open feature: Stainless steel hold open device shall be provided to lock the cover in the fully open 90 degree position.
   7. Lift mechanism and hardware: Stainless steel lifting mechanisms as specified above for all fall protection panels that weigh over 50 pounds.
   8. Grating openings: Reinforced with easy-open aluminum covers for removal of instrumentation below access doors.

2.05 FINISHES

A. Door and frame: Mill finish aluminum with heavy bituminous coating where in contact with concrete.

B. Telescopic safety post: aluminum or stainless steel.

C. Springs: Electro-coated acrylic finish.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and openings for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Installation shall conform to the manufacturer’s recommendations.

B. Frame shall be accurately cast in place and securely anchored to concrete. Installation of access doors after concrete is placed is not allowed.

C. Set frame level, plumb and in proper alignment with adjacent work.

D. Contractor shall field route a 1.5 inch Schedule 80 PVC drain pipe from the 1.5 inch drain coupling on all access doors to the water or floor level below. Place drain pipe clear of the access area below the door and as approved by the Owner's Representative.

3.03 REPAIR/RESTORATION

A. Repair finishes damaged during installation.

B. Remove and replace doors that are warped, bowed, or otherwise damaged.

3.04 ADJUSTING

A. Adjust doors and hardware after installation for proper operation.

3.05 CLEANING

A. Clean exposed surfaces using methods acceptable to the manufacturer that will not damage finish.

3.06 FLOOR ACCESS DOOR SCHEDULE

A. See Structural Drawings.

END OF SECTION

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SECTION 08 33 23

OVERHEAD COILING DOORS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Insulated 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.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.
   1. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
   2. Show locations of controls, locking devices detectors or replaceable fusible links, and other accessories.
   3. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.03 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.04 CLOSEOUT SUBMITTALS

A. Special warranty.
   1. Provide documentation of special warranty signed by manufacturer

B. Maintenance data.

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.

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 PERFORMANCE REQUIREMENTS

A. 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.

2.02 DOOR ASSEMBLY

A. Insulated Service Door: Overhead coiling door formed with curtain of interlocking metal slats.
   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. Clopay Building Products.
      b. Cookson; a CornellCookson company.
      c. Cornell; a CornellCookson company.
      d. Overhead Door Corporation.
      e. Raynor Garage Doors.
      f. Wayne Dalton; a division of Overhead Door Corporation.
      g. Or approved equal.

B. Operation Cycles: Door components and operators capable of operating for not less than 10,000.

C. Insulated Door Curtain R-Value: 4.5 deg F x h x sq. ft./Btu.

D. Door Curtain Material: Galvanized steel.

E. Door Curtain Slats: Flat profile slats of 1-7/8-inch center-to-center height.
   1. Insulated-Slat Interior Facing: Metal.

F. Bottom Bar: Two angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch thick; fabricated from hot-dip galvanized steel and finished to match door.

G. Curtain Jamb Guides: Galvanized steel with exposed finish matching curtain slats.

H. Hood: Match curtain material and finish.
   1. Mounting: Face of wall.

I. Electric Door Operator:
   1. Usage Classification: Medium duty, up to 12 cycles per hour and up to 50 cycles per day.
   2. Safety: Listed according to UL 325 by a qualified testing agency for commercial or industrial use.
   3. Motor Exposure: Interior.
   4. Motor Electrical Characteristics:
      a. Horsepower: 1/2 hp.
      b. Voltage: 115 V ac, single phase, 60 Hz.
   5. Emergency Manual Operation: Chain type.
   6. Obstruction-Detection Device: Automatic electric sensor edge on bottom bar; self-monitoring type.
   7. Control Station(s): Interior mounted.

J. Curtain Accessories: Equip door with weather-seals.

K. Door Finish:
   1. Baked-Enamel or Powder-Coated Finish: Color as selected by Engineer from manufacturer's full range.
   2. Interior Curtain-Slat Facing: Match finish of exterior curtain-slat face.

2.03 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.

2.04 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. 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.
   2. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face, with minimum steel thickness of 0.010 inch.

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.

2.05 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 project beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.

2.06 CURTAIN ACCESSORIES

A. Weather-seals 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.

2.07 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. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

2.08 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. Motors: Reversible-type motor with controller (disconnect switch) 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. and not more than 12 in./sec., without exceeding nameplate ratings or service factor.
   2. Operating Controls, Controllers, Disconnect Switches, Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.

D. 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.
   1. Electric Sensor Edge: Automatic safety sensor edge, located within astragal or weather stripping mounted to bottom bar. Contact with sensor activates device. Connect to control circuit using manufacturer's standard take-up reel or self-coiling cable.
      a. Self-Monitoring Type: Four-wire-configured device designed to interface with door operator control circuit to detect damage to or disconnection of sensor edge.

E. 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. Interior-Mounted Units: Full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.

F. 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.

G. 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.

H. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.

PART 3 EXECUTION

3.01 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. Power-Operated Doors: Install automatic garage doors openers according to UL 325.

3.02 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and to furnish reports to Architect.

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.

3.03 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 43 13

ALUMINUM-FRAMED STOREFRONTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Aluminum-framed storefront systems.

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.
   2. For recycled content, indicating post-consumer and pre-consumer
   3. recycled content and cost.

B. Shop Drawings: For aluminum-framed storefronts. Include plans, elevations, sections, full-size details, and attachments to other work.
   1. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

C. Samples: For each type of exposed finish required.

D. Delegated-Design Submittal: For aluminum-framed storefronts indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 INFORMATIONAL SUBMITTALS

A. Energy Performance Certificates: NFRC-certified energy performance values from manufacturer.

B. Product test reports. for tests performed by qualified testing agency

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: 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 (AGM) contractors.

B. Testing Agency Qualifications: Qualified in accordance with ASTM E699 for testing indicated and acceptable to Owner and Architect.

C. 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 Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

1.07 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 10 years from date of Substantial Completion.

B. Special Finish Warranty, Anodized Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of anodized finishes within specified warranty period.
   1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer Company, Inc.; Arconic Corporation; Trifab Versaglaze 451T Framing System with GLASSvent Project-Out Windows or a comparable product by one of the following:
   1. Boyd Aluminum Mfg. Co.
   2. CMI Architectural Products, Inc.
   3. EFCO Corporation.
   4. Manko Window Systems, Inc.
   5. Pittco Architectural Metals, Inc.
   6. Trulite Glass & Aluminum Solutions, LLC.
   7. Tubelite Inc.
   8. U.S. Aluminum; C.R. Laurence Co., Inc.; CRH Americas, Inc.
   9. YKK AP America Inc.
   10. Or approved equal.

2.02 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 45 00 "Contractor Quality Control," to design aluminum-framed storefronts.

B. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.
   1. Aluminum-framed 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.

C. Structural Loads:
   1. Wind Loads: As indicated on Drawings.
   2. Other Design Loads: As indicated on Drawings.

D. 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 and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches
   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.
      a. Operable Units: Provide a minimum 1/16-inch clearance between framing members and operable units.
   3. Cantilever Deflection: Limited to 2l/175 at unsupported cantilevers.

E. Structural: Test in accordance with ASTM E330/E330M as follows:
   1. When tested at positive and negative wind-load design pressures, storefront assemblies do not evidence deflection exceeding specified limits.
   2. When tested at 150 percent of positive and negative wind-load design pressures, storefront assemblies, including 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.

F. 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 when tested in accordance with a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft..

G. Energy Performance: Certified and labelled 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 0.45 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 0.38 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. at a static-air-pressure differential of 6.24 lbf/sq. ft. when tested in accordance with ASTM E283.
   4. Condensation Resistance Factor (CRF):
      a. Fixed Glazing and Framing Areas: CRF for the system of not less than 55 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, ambient; 180 deg F, material surfaces.

2.03 ALUMINUM-FRAMED STOREFRONT SYSTEMS

A. 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 four sides.
   3. Glazing Plane: Front.
   4. Finish: Clear anodic 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.

B. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

2.04 WINDOW SYSTEM

A. GLASSvent Windows - Project-Out.

B. Hardware
   1. General: Provide manufacturer's standard hardware fabricated from aluminum, stainless steel, or other corrosion-resistant material compatible with aluminum; designed to smoothly operate, tightly close, and securely lock aluminum windows, and sized to accommodate sash weight and dimensions.

2. Project-Out Windows: Provide the following operating hardware:
    a. Stainless Steel 4-Bar Hinges
    b. Cast White Bronze Cam Locking Handles

C. Accessories
1. Spacers, Setting Blocks, Gaskets, and Bond Breakers: Manufacturer's standard permanent, non-migrating types in hardness recommended by manufacturer, compatible with sealants, and suitable for system performance requirements.
2. Framing system gaskets, sealants, and joint fillers as recommended by manufacturer for joint type.
3. Sealants and joint fillers for joints at perimeter of window system as specified in Section 07 92 00 “Joint Sealants”.
4. Insect Screens: Extruded aluminum frames, 6063-T6 alloy and temper, joined at corners: 18 x 16 mesh fiberglass screen cloth; frames finished to match aluminum windows; splines shall be extruded vinyl, removable to permit rescreening.

D. Fabrication
1. Window Vent and/or Vent Frame Joinery: Mitered and Mechanically clipped and/or staked. Factory sealed vent and /or vent frame and corner joints.
2. Fabricate aluminum windows in sizes indicated. Include a complete system for assembling components and anchoring windows.

2.05 GLAZING

A. Glazing: Comply with Section 08 80 00 "Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Glazing Sealants: As recommended by manufacturer.

2.06 MATERIALS

A. Sheet and Plate: ASTM B209.

B. Extruded Bars, Rods, Profiles, and Tubes: ASTM B221.

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.

2.07 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. Provisions for field replacement of glazing from exterior.
   6. 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. After fabrication, clearly mark components to identify their locations in Project in accordance with Shop Drawings.

2.08 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 EXECUTION

3.01 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.

3.02 INSTALLATION OF GLAZING

A. Install glazing as specified in Section 08 80 00 "Glazing."

3.03 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Field Quality-Control Testing: Perform the following test on representative areas of aluminum-framed storefronts.
   1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Architect shall be tested in accordance with AAMA 501.2 and shall not evidence water penetration.
      a. Perform a minimum of three tests in areas as directed by Architect.
   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. at a static-air-pressure differential of 1.57 lbf/sq. ft..
      a. Perform a minimum of three tests in areas as directed by Architect.
   3. Water Penetration: ASTM E1105 at a minimum uniform and cyclic 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., and shall not evidence water penetration.

C. Aluminum-framed storefronts will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

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SECTION 08 45 13

FIBERGLASS WALL PANEL SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the insulated translucent sandwich panel system and accessories, factory unitized, as shown and specified. Work includes providing and installing:
   1. Flat factory prefabricated structural insulated translucent sandwich panels
   2. Aluminum installation system
   3. Aluminum sill flashing

B. Related Requirements
   1. Section 07900: Joint Sealants

1.02 SUBMITTALS

A. Submit manufacturer's product data. Include construction details, material descriptions, profiles and finishes of components.

B. Submit shop drawings. Include elevations and details.

C. Submit manufacturer's color charts showing the full range of colors available for factory-finished aluminum.
   1. When requested, submit samples for each exposed finish required, in same thickness and material indicated for the work and in size indicated below. If finishes involve normal color variations, include sample sets consisting of two or more units showing the full range of variations expected.
      a. Sandwich panels: 14" x 28" units
      b. Factory finished aluminum: 5" long sections

D. Submit Installer Certificate, signed by installer, certifying compliance with project qualification requirements.

E. Submit product reports from a qualified independent testing agency indicating each type and class of panel system complies with the project performance requirements, based on comprehensive testing of current products. Previously completed reports will be acceptable if for current manufacturer and indicative of products used on this project.
   1. Reports required are:
      a. International Building Code Evaluation Report
      b. Flame Spread and Smoke Developed (UL 723) – Submit UL Card
      c. Burn Extent (ASTM D 635)
      d. Color Difference (ASTM D 2244)
      e. Impact Strength (UL 972)
      f. Bond Tensile Strength (ASTM C 297 after aging by ASTM D 1037)
      g. Bond Shear Strength (ASTM D 1002)

h. Beam Bending Strength (ASTM E 72)
i. Insulation U-Factor (NFRC 100)
j. NFRC System U-Factor Certification (NFRC 700)
k. Solar Heat Gain Coefficient (NFRC or Calculations)
l. Condensation Resistance Factor (AAMA 1503)
m. Air Leakage (ASTM E 283)
n. Structural Performance (ASTM E 330)
o. Water Penetration (ASTM E 331)
p. 1200°F Fire Resistance (SWRI)
q. ASTM E1886/1996 or TAS 201, 202 and 203
r. Performance for Windows (AAMA/WDMA/CSA-101/I.S.2/A440-05)

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications

1. Material and products shall be manufactured by a company continuously and regularly employed in the manufacture of specified materials for a period of at least ten consecutive years and which can show evidence of those materials being satisfactorily used on at least six projects of similar size, scope and location. At least three of the projects shall have been in successful use for ten years or longer.
2. Panel system must be listed by an ANSI accredited Evaluation Service, which requires quality control inspections and fire, structural and water infiltration testing of sandwich panel systems by an accredited agency.
3. Quality control inspections shall be conducted at least once each year and shall include manufacturing facilities, sandwich panel components and production sandwich panels for conformance with AC177 “Translucent Fiberglass Reinforced Plastic (FRP) Faced Panel Wall, Roof and Skylight Systems” as issued by the ICC-ES.

B. Installer’s Qualifications: Installation shall be by an experienced installer, which has been in the business of installing specified panel systems for at least two consecutive years and can show evidence of satisfactory completion of projects of similar size, scope and type.

1.04 PERFORMANCE REQUIREMENTS

A. The manufacturer shall be responsible for the configuration and fabrication of the complete unitized panel system.
1. When requested, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Standard panel system shall have less than 0.01 cfm/ft^2 air leakage by ASTM E 283 at 6.24 PSF (50 mph) and no water penetration by ASTM E 331 at 15 PSF; and structural testing by ASTM E 330.
3. Structural Loads; Provide system capable of handling the following loads:
a. Positive Wind Load: As indicated on Structural Drawings.
b. Negative Wind Load: As indicated on Structural Drawings.
c. Seismic Design Criteria: As indicated on Structural Drawings.

1.05 DELIVERY STORAGE AND HANDLING

A. Deliver panel system, components and materials in manufacturer's standard protective packaging.

B. Store panels on the long edge; several inches above the ground, blocked and under cover in accordance with manufacturer's storage and handling instructions.

1.06 WARRANTY

A. Submit manufacturer's and installer's written warranty agreeing to repair or replace panel system work, which fails in materials or workmanship within one year of the date of delivery. Failure of materials or workmanship shall include leakage, excessive deflection, deterioration of finish on metal in excess of normal weathering, defects in accessories, insulated translucent sandwich panels and other components of the work.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. The basis for this specification is for products manufactured by Kalwall Corporation. Other manufacturers may bid this project provided they comply with all of the performance requirements of this specification and submit evidence thereof. Listing other manufacturers' names in this specification does not constitute approval of their products or relieve them of compliance with all the performance requirements contained herein.

B. Kalwall Corporation, Tel: (800) 258-9777 – Email: info@kalwall.com

2.02 PANEL COMPONENTS

A. Face Sheets
   1. Translucent faces: Manufactured from glass fiber reinforced thermoset resins, formulated specifically for architectural use.
      a. Thermoplastic (e.g. polycarbonate, acrylic) faces are not acceptable.
      b. Face sheets shall not deform, deflect or drip when subjected to fire or flame.
   2. Interior face sheets:
      a. Flame spread: Underwriters Laboratories (UL) listed, which requires periodic unannounced retesting, with flame spread rating no greater than 25 and smoke developed no greater than 250 when tested in accordance with UL 723.
      b. Burn extent by ASTM D 635 shall be no greater than 1".
   3. Exterior face sheets:
      a. Color stability: Full thickness of the exterior face sheet shall not change color more than 3 CIE Units DELTA E by ASTM D 2244 after 5 years outdoor South Florida weathering at 5° facing south, determined by the average of at least three white samples with and without a protective film or coating to ensure long-term color stability. Color stability shall be unaffected by abrasion or scratching.
      b. Strength: Exterior face sheet shall be uniform in strength, with panel meeting ASTM E1996 and ASTM E1886 or TAS 201, 202 and 203.

4. Appearance
    a. Exterior face sheets: Smooth 0.070” thick and Crystal in color.
    b. Interior face sheets: Smooth 0.045” thick and Crystal in color.
    c. Face sheets shall not vary more than ± 10% in thickness and be uniform in color.

B. Grid Core
1. Thermally Broken Composite I-beam grid core shall be of 6063-T6 or 6005-T5 alloy and temper with provisions for mechanical interlocking of muntin-mullion and perimeter. Width of I-beam shall be no less than 7/16”.
2. I-beam Thermal break: Minimum 1”, thermoset fiberglass composite.

C. Laminate Adhesive
1. Heat and pressure resin type adhesive engineered for structural sandwich panel use, with minimum 25-years field use. Adhesive shall pass testing requirements specified by the International Code Council “Acceptance Criteria for Sandwich Panel Adhesives”.
2. Minimum tensile strength of 750 PSI when the panel assembly is tested by ASTM C 297 after two exposures to six cycles each of the aging conditions prescribed by ASTM D 1037.
3. Minimum shear strength of the panel adhesive by ASTM D 1002 after exposure to four separate conditions:
    a. 50% Relative Humidity at 68° F: 540 PSI
    b. 182° F: 100 PSI
    c. Accelerated Aging by ASTM D 1037 at room temperature: 800 PSI
    d. Accelerated Aging by ASTM D 1037 at 182° F: 250 PSI

2.03 PANEL CONSTRUCTION

A. Provide sandwich panels of flat fiberglass reinforced translucent face sheets laminated to a grid core of mechanically interlocking I-beams. The adhesive bonding line shall be straight, cover the entire width of the I-beam and have a neat, sharp edge.
1. Thickness: 2-3/4”
2. Light transmission: 10%
3. Solar heat gain coefficient 0.13.
4. Panel U-factor by NFRC certified laboratory: 2-3/4” thermally broken grid 0.10 U-factor.
5. Grid pattern: Nominal size 8” x 20”; pattern Shoji.

B. Standard panels shall deflect no more than 1.9” at 30 PSF in 10’ 0” span without a supporting frame by ASTM E 72.

C. Standard panels shall withstand 1200° F fire for minimum one hour without collapse or exterior flaming.

D. Thermally broken panels: Minimum Condensation Resistance Factor of 80 by AAMA 1503 measured on the bond line.
   1. Manufacturer's factory applied finish, which meets the performance requirements of AAMA 2604. Color to be selected from manufacturer's standards.

E. Finish is to be coordinated with closure system.

PART 3 EXECUTION

3.01 EXAMINATION

A. Installer shall examine substrates, supporting structure and installation conditions.

B. Do not proceed with panel installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Metal Protection
   1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.

   2. Where aluminum will contact concrete, masonry or pressure treated wood, protect against corrosion by painting contact surfaces with bituminous paint or method recommended by manufacturer.

3.03 INSTALLATION

A. Install the panel system in accordance with the manufacturer's suggested installation recommendations and approved shop drawings.
   1. Anchor component parts securely in place by permanent mechanical attachment system.
   2. Accommodate thermal and mechanical movements.
   3. Set perimeter framing in a full bed of sealant compound, or with joint fillers or gaskets to provide weather-tight construction

B. Install joint sealants at perimeter joints and within the panel system in accordance with manufacturer's installation instructions.

3.04 CLEANING

A. Clean the panel system interior and exterior, immediately after installation.

B. Refer to manufacturer's written recommendations.

END OF SECTION

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SECTION 08 71 00

DOOR HARDWARE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Hardware for aluminum and hollow metal doors.

B. Hardware for fire-rated doors.

C. Electrically operated and controlled hardware.

D. Lock cylinders for doors with balance of hardware specified in other sections.

E. Thresholds.

F. Weatherstripping and gasketing.

1.02 RELATED REQUIREMENTS

A. Section 08 11 13 - Hollow Metal Doors and Frames.

B. Section 28 10 00 - Access Control: Electronic access control devices.

1.03 REFERENCE STANDARDS

A. ADA Standards - 2010 ADA Standards for Accessible Design; 2010.

B. ASTM E283/E283M - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; 2019.

C. BHMA A156.1 - Standard for Butts and Hinges; 2021.

D. BHMA A156.2 - Bored and Preassembled Locks and Latches; 2022.

E. BHMA A156.3 - Exit Devices; 2020.

F. BHMA A156.4 - Door Controls - Closers; 2019.

G. BHMA A156.5 - Cylinders and Input Devices for Locks; 2020.

H. BHMA A156.6 - Standard for Architectural Door Trim; 2021.

I. BHMA A156.7 - Template Hinge Dimensions; 2016.

J. BHMA A156.16 - Auxiliary Hardware; 2018.

K. BHMA A156.18 - Materials and Finishes; 2020.

L. BHMA A156.21 - Thresholds; 2019.

M. BHMA A156.22 - Standard for Gasketing; 2021.

N. BHMA A156.28 - Standard for Recommended Practices for Mechanical Keying Systems; 2018.

O. BHMA A156.115 - Hardware Preparation in Steel Doors and Steel Frames; 2016.

P. BHMA A156.115W - Hardware Preparation in Wood Doors with Wood or Steel Frames; 2006.

Q. DHI (H&S) - Sequence and Format for the Hardware Schedule; 2019.

R. DHI (KSN) - Keying Systems and Nomenclature; 2019.

S. DHI (LOCS) - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames; 2004.

T. DHI WDHS.3 - Recommended Locations for Architectural Hardware for Flush Wood Doors; 1993; also in WDHS-1/WDHS-5 Series, 1996.

U. ICC A117.1 - Accessible and Usable Buildings and Facilities; 2017.

V. ITS (DIR) - Directory of Listed Products; Current Edition.

W. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; 2019h.

X. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

Y. NFPA 80 - Standard for Fire Doors and Other Opening Protectives; 2022.

Z. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives; 2022.

AA. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies; 2022.

BB. UL (DIR) - Online Certifications Directory; Current Edition.

CC. UL 10C - Standard for Positive Pressure Fire Tests of Door Assemblies; Current Edition, Including All Revisions.

DD. UL 294 - Access Control System Units; Current Edition, Including All Revisions.

EE. UL 1784 - Standard for Air Leakage Tests of Door Assemblies; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordinate the manufacture, fabrication, and installation of products that door hardware is installed on.

B. Sequence installation to ensure facility services connections are achieved in an orderly and expeditious manner.

C. Preinstallation Meeting: Convene a preinstallation meeting one week prior to commencing work of this section; require attendance by affected installers and the following:
   1. Engineer.
   2. Supplier's Architectural Hardware Consultant (AHC).
   3. Hardware Installer.
   4. Owner's Security Consultant.

D. Furnish templates for door and frame preparation to manufacturers and fabricators of products requiring internal reinforcement for door hardware.

E. Keying Requirements Meeting:
   1. Schedule meeting at project site prior to Contractor occupancy.
   2. Attendance Required:
      a. Owner.
   3. Agenda:
      a. Establish keying requirements.
      b. Verify locksets and locking hardware are functionally correct for project requirements.
      c. Verify that keying and programming complies with project requirements.
      d. Establish keying submittal schedule and update requirements.
   4. Incorporate "Keying Requirements Meeting" decisions into keying submittal upon review of door hardware keying system including, but not limited to, the following:
   5. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.
   6. Deliver established keying requirements to manufacturers.

1.05 SUBMITTALS

A. See Section 01 33 00 – Submittal Procedures for submittal procedures.

B. Product Data: Manufacturer's catalog literature for each type of hardware, marked to clearly show products to be furnished for this project, and includes construction details, material descriptions, finishes, and dimensions and profiles of individual components.

C. Shop Drawings - Door Hardware Schedule: A detailed listing that includes each item of hardware to be installed on each door.
   1. Prepared by or under supervision of Architectural Hardware Consultant (AHC).
   2. Comply with DHI (H&S) using door numbering scheme and hardware set numbers as indicated in Contract Documents.
      a. Submit in vertical format.
   3. Include complete description for each door listed.

D. Shop Drawings - Electrified Door Hardware: Include diagrams for power, signal, and control wiring for electrified door hardware that include details of interface with building safety and security systems. Provide elevations and diagrams for each electrified door opening as follows:
   1. Prepared by or under supervision of Architectural Hardware Consultant (AHC) and Electrified Hardware Consultant (EHC).
   2. Elevations: Include front and back elevations of each door opening showing electrified devices with connections installed and an operations narrative describing how opening operates from either side at any given time.
   3. Diagrams: Include point-to-point wiring diagrams that show each device in door opening system with related colored wire connections to each device.

E. Manufacturer's Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.

F. Manufacturer's qualification statement.

G. Installer's qualification statement.

H. Supplier's qualification statement.

I. Maintenance Data: Include data on operating hardware, lubrication requirements, and inspection procedures related to preventative maintenance.

J. Keying Schedule:
   1. Submit three (3) copies of Keying Schedule in compliance with requirements established during Keying Requirements Meeting unless otherwise indicated.

K. Warranty: Submit manufacturer's warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

L. Project Record Documents: Record actual locations of concealed equipment, services, and conduit.

M. Maintenance Materials and Tools: Furnish the following for Owner's use in maintenance of project.

1.06 QUALITY ASSURANCE

A. Standards for Fire-Rated Doors: Maintain one copy of each referenced standard on site, for use by Architect and Contractor.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.

C. Installer Qualifications: Company specializing in performing work of the type specified for commercial door hardware with at least three years of documented experience.

D. Supplier Qualifications: Company with certified Architectural Hardware Consultant (AHC) and Electrified Hardware Consultant (EHC) to assist in work of this section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Package hardware items individually; label and identify each package with door opening code to match door hardware schedule.

1.08 WARRANTY

A. See Section 01 78 23 – Operation and Maintenance Data for additional warranty requirements.

B. Manufacturer Warranty: Provide manufacturer warranty against defects in material and workmanship for period indicated, from Date of Substantial Completion. Complete forms in Owner's name and register with manufacturer.
   1. Closers: Ten years, minimum.
   2. Exit Devices: Three years, minimum.
   3. Locksets and Cylinders: Lifetime
   4. Other Hardware: Two years, minimum.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide specified door hardware as required to make doors fully functional, compliant with applicable codes, and secure to extent indicated.

B. Provide individual items of single type, of same model, and by same manufacturer.

C. Locks: Provide a lock for each door, unless it's indicated that lock is not required.
   1. Lock Function: Provide lock and latch function numbers and descriptions of manufacturer's Series. As indicated in hardware sets.
   2. Trim: Provide lever handle or pull trim on outside of each lock, unless otherwise indicated.
   3. Strikes:
      a. Finish: To match lock or latch.
      b. Curved-Lip Strikes: Provide as standard, with extended lip to protect frame, unless otherwise indicated.
      c. Center Strike At Pairs of Doors: 7/8 inch (22.2 mm) lip.

D. Closers:
   1. Provide door closer on each exterior door, unless otherwise indicated.
   2. Provide door closer on each fire-rated and smoke-rated door.
   3. Spring hinges are not an acceptable self-closing device, unless otherwise indicated.

E. Overhead Stops and Holders (Door Checks):.
   1. Provide stop for every swinging door, unless otherwise indicated.
   2. Overhead Stop is not required if positive stop feature is specified for door closer; positive stop feature of door closer is not an acceptable substitute for a stop, unless otherwise indicated.

3. Overhead stop is not required if a floor or wall stop has been specified for the door.

F. Drip Guards: Provide at head of out-swinging exterior doors unless protected by roof or canopy directly overhead.

G. Thresholds:
   1. Exterior Applications: Provide at each exterior door, unless otherwise indicated.

H. Weatherstripping and Gasketing:
   1. Provide weatherstripping on each exterior door at head, jambs, and meeting stiles of door pairs, unless otherwise indicated.
   2. Provide door bottom sweep on each exterior door, unless otherwise indicated.

I. Electrically Operated and/or Controlled Hardware: Provide necessary power supplies, power transfer hinges, relays, and interfaces as required for proper operation; provide wiring between hardware and control components and to building power connection in compliance with NFPA 70.

J. See Section 28 10 00 for additional access control system requirements.

K. Fasteners:
   1. Provide fasteners of proper type, size, quantity, and finish that comply with commercially recognized standards for proposed applications.
      a. Aluminum fasteners are not permitted.
      b. Provide phillips flat-head screws with heads finished to match door surface hardware unless otherwise indicated.
   2. Provide machine screws for attachment to reinforced hollow metal and aluminum frames.
      a. Self-drilling (Tek) type screws are not permitted.
   3. Provide stainless steel machine screws and lead expansion shields for concrete and masonry substrates.
   4. Provide wall grip inserts for hollow wall construction.
   5. Fire-Resistance-Rated Applications: Comply with NFPA 80.
      a. Provide wood or machine screws for hinges mortised to doors or frames, strike plates to frames, and closers to doors and frames.
      b. Provide steel through bolts for attachment of surface mounted closers, hinges, or exit devices to door panels unless proper door blocking is provided.

2.02 PERFORMANCE REQUIREMENTS

A. Provide door hardware products that comply with the following requirements:
   1. Applicable provisions of federal, state, and local codes.
   2. Accessibility: ADA Standards and ICC A117.1.
   3. Fire-Resistance-Rated Doors: NFPA 80, listed and labeled by qualified testing agency for fire protection ratings indicated, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.

4. Hardware on Fire-Resistance-Rated Doors: Listed and classified by UL (DIR), ITS (DIR), testing firm acceptable to authorities having jurisdiction, or as suitable for application indicated.
5. Hardware for Smoke and Draft Control Doors (Indicated as "S" on Drawings): Provide door hardware that complies with local codes, and requirements of assemblies tested in accordance with UL 1784.
6. Hardware Preparation for Steel Doors and Steel Frames: BHMA A156.115.
7. Hardware Preparation for Wood Doors with Wood or Steel Frames: BHMA A156.115W.
8. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified.

2.03 HINGES

A. Manufacturers: Conventional butt hinges.
   1. BEST; Dormakaba Group: www.bestaccess.com/#sle.
   2. Or approved equal.

B. Properties:
   1. Butt Hinges: As applicable to each item specified.
      a. Standard Weight Hinges: Minimum of two (2) permanently lubricated non-detachable bearings.
      b. Heavy Weight Hinges: Minimum of four (4) permanently lubricated bearings on heavy weight hinges.
      c. Template screw hole locations.
      d. Bearing assembly installed after plating.
      e. Bearings: Exposed fully hardened bearings.
      f. Bearing Shells: Shapes consistent with barrels.
      g. Pins: Easily seated, non-rising pins.
         1) Fully plate hinge pins.
         2) Non-Removable Pins: Slotted stainless steel screws.
      h. UL 10C listed for fire-resistance-rated doors.

C. Sizes: See Door Hardware Schedule.
   1. Hinge Widths: As required to clear surrounding trim.
   2. Sufficient size to allow 180 degree swing of door.

D. Finishes: See Door Hardware Schedule.
   1. Fully polish hinges; front, back, and barrel.

E. Grades:
   1. Butt Hinges: Comply with BHMA A156.1 and BHMA A156.7 for templated hinges.
   2. Comply with BHMA A156.18 Materials and Finishes.

F. Material: Base metal as indicated for each item by BHMA material and finish designation.

G. Types:
   1. Butt Hinges: Include full mortise hinges.

H. Options: As applicable to each item specified.

I. Quantities:
   1. Butt Hinges: Three (3) hinges per leaves up to 90 inches (2286 mm) in height. Add one (1) for each additional 30 inches (762 mm) in height or fraction thereof.
      a. Hinge weight and size unless otherwise indicated in hardware sets:
         1) For doors up to 36 inches (914 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.134 inch (3.4 mm) and a minimum of 4-1/2 inches (114 mm) in height.
         2) For doors from 36 inches (914 mm) wide up to 42 inches (1067 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.145 inch (3.7 mm) and a minimum of 4-1/2 inches (114 mm) in height.
         3) For doors from 42 inches (1067 mm) wide up to 48 inches (1219 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.
         4) For doors greater than 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.

J. Applications: At swinging doors.
   1. Provide non-removable pins at out-swinging doors with locking hardware and all exterior doors.

K. Products:
   1. Butt Hinges:
      a. Ball Bearing, Five (5) Knuckle.

2.04 BOLTS

A. Manufacturers:
   1. Trimco: www.trimcohardware.com/#sle.

B. Properties:
   1. Flush Bolts:
      a. Automatic Flush Bolts: Automatically latching upon closing of door leaf.
         1) Bolt Throw: 3/4 inch (19 mm), minimum.
   2. Dustproof Strikes: For bolting into floor, provide except at metal thresholds.

C. Options:
   1. Lever extensions: Provide for top bolt at oversized doors.

D. Products:
   1. Automatic flush bolts: 3810.

2.05 EXIT DEVICES

A. Manufacturers:
   1. BEST, dormakaba Group: www.bestaccess.com/#sle.
   2. Substitutions: Not permitted.

B. Properties:
   1. Actuation: Full-length touchpad.
   2. Touchpads: 'T" style metal touchpads and rail assemblies with matching chassis covers end caps.
   3. Latch Bolts: Stainless steel deadlocking with 3/4 inch (19 mm) projection using latch bolt.
   4. Lever Design: Match project standard lockset trims.
   5. Cylinder: Include where cylinder dogging or locking trim is indicated.
   6. Strike as recommended by manufacturer for application indicated.
   7. Sound dampening on touch bar.
   8. Dogging:
      a. Non-Fire-Resistance-Rated Devices: Cylinder 1/4 inch (6 mm) hex key dogging.
      b. Fire-Resistance-Rated Devices: Manual dogging not permitted.
   9. Touch bar assembly on wide style exit devices to have a 1/4 inch (6.3 mm) clearance to allow for vision frames.
   10. All exposed exit device components to be of architectural metals and "true" architectural finishes.
   11. Handing: Field-reversible.
   12. Fasteners on Back Side of Device Channel: Concealed - exposed fasteners not allowed.
   13. Vertical Latch Assemblies' Operation: Gravity, without use of springs.

C. Grades: Complying with BHMA A156.3, Grade 1.
   1. Provide exit devices tested and certified by UL or by a recognized independent laboratory for mechanical operational testing to 10 million cycles minimum with inspection confirming Grade 1 Loaded Forces have been maintained.

D. Options:
   1. Electrified Devices:
      a. Latchbolt Retraction: motorized latchbolt retraction.
   2. Furnish less bottom rod (LBR) at scheduled locations to eliminate use of floor mounted strikes.
   3. Weatherized True Architectural Finish: Provide where indicated in Door Hardware Schedule as 626W.
      a. Weatherized exterior components to include active case cover, touch bar, device channel, slide channel fillers, vertical rods, latch covers, and device end cap.
         1) Base Metal Material: Brass.
         2) Plated Finish: Satin nickel and chrome, using a double-dip, two-step process.

b. Performance Requirements:
   1) BHMA A156.18 Salt Spray Certified using 600 Hours of testing, 3 times longer than the Standard's requirements.
   2) MIL-STD-810G 509.6 Salt Fog Certified.
   3) MIL-STD-810G 510.6 Sand and Dust Certified.
   4) MIL-STD-810G 521.4 Icing or Freezing Rain Certified.
c. Compatible non-weatherized electrified options as specified in Door Hardware Schedule.

4. WTS touch bar switch.
5. WALW hardwired exit alarm.

E. Products:
1. 2000.

2.06 LOCK CYLINDERS

A. Manufacturers:
1. BEST, dormakaba Group: www.bestaccess.com/#sle.
2. Substitutions: Not permitted.

B. Properties:
1. Lock Cylinders: Provide key access on outside of each lock, unless otherwise indicated.
   a. Provide cylinders from same manufacturer as locking device.
   b. Provide cams and/or tailpieces as required for locking devices.
   c. Provide cylinders with appropriate format interchangeable cores where indicated.

C. Grades:
1. Standard Security Cylinders: Comply with BHMA A156.5.

D. Material:

E. Types: As applicable to each item specified.

F. Applications: At locations indicated in hardware sets, and as follows
1. As required for items with locking devices provided by other sections, including at elevator controls and cabinets.
   a. When provisions for lock cylinders are referenced elsewhere in the Project Manual to this Section, provide compatible type of lock cylinder, keyed to building keying system, unless otherwise indicated.

G. Products:
1. Rim/mortise: 12E-72 & 1E-74

2.07 MORTISE LOCKS

A. Manufacturers:
   1. BEST, dormakaba Group: www.bestaccess.com/#sle.
   2. Substitutions: Not permitted.

B. Properties:
   1. Mechanical Locks: Manufacturer's standard.
      a. Fitting modified ANSI A115.1 door preparation.
      b. Door Thickness Coordination Fitting 1-3/4 inch (44 mm) to 2-1/4 inch (57 mm) thick doors.
      c. Latch: Solid, one-piece, anti-friction, self-lubricating stainless steel.
         1) Latchbolt Throw: 3/4 inch (19 mm), minimum.
      d. Auxiliary Deadlatch: One piece stainless steel, permanently lubricated.
      e. Backset: 2-3/4 inch (70 mm).
      f. Lever Trim:
         1) Functionality: Allow the lever handle to move up to 45 degrees from horizontal position prior to engaging the latchbolt assembly.
         2) Strength: Locksets outside locked lever designed to withstand minimum 1,400 inch-lbs (158.2 Nm) of torque. In excess of that, a replaceable part will shear. Key from outside and/or inside lever will still operate lockset.
         3) Spindle: Designed to prevent forced entry from attacking of lever.
         4) Independent spring mechanism for each lever.
            a) Trim to be self-aligning and thru-bolted.
         5) Handles: Made of forged or cast brass, bronze, or stainless steel construction. Levers that contain a hollow cavity are not acceptable.
         6) Levers to operate a roller bearing spindle hub mechanism.
   2. Electrified Locks: Same properties as standard locks, and as follows:
      a. Voltage: 24 VAC.
      b. Function: Electrically locked (Fail Safe) or unlocked (Fail Secure), as indicated for each lock in Door Hardware Schedule.

C. Finishes: See Door Hardware Schedule.
   1. Core Faces: Match finish of lockset.

D. Grades:

E. Options:
   1. Provide locksets made in a manufacturing facility to compliant with ISO 9001-Quality Management and ISO 14001-Environmental Management.

F. Products: Mortise locks, including standard and electrified types.
   1. 40H.

2.08 COORDINATORS

A. Manufacturers:
   1. Trimco: www.trimcohardware.com/#sle.

B. Properties:
   1. General: Non-handed devices, with field-selectable active door leaf.
   2. Coordinators: Devices on pairs of doors with closers and self-latching or automatic flush bolts installed.
      a. Coordinator Operation: Only when inactive door is opened.

C. Grades:

D. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.
   1. Meet UL 10C for Positive Pressure.

E. Types:
   1. Coordinators: Bar.

F. Installation:
   1. Mounting: Provide necessary mounting brackets and filler bars to ensure proper installation of coordinator and related hardware.
   2. Coordination: Properly sequence installation of other door hardware affected by placement of coordinators and carry bars.

G. Products:
   1. 3090 Series.

2.09 CLOSERS

A. Manufacturers:
   1. dormakaba; dormakaba Group: www.dormakaba.com/us-en/#sle.
   2. Substitutions: Not permitted.

B. Properties:
   1. Surface Mounted Closers: Manufacturer's standard.
      a. Construction: R14 high silicon aluminum alloy.
      b. Mechanism: Separate tamper-resistant adjusting valves for closing and latching speeds.
      c. Hydraulic Fluid: All-weather type.
      d. Arm Assembly: Standard for product specified.
         1) Include hold-open, integral stop, or spring-loaded stop feature, as specified in Door Hardware Schedule.
         2) Parallel arm to be a heavy-duty rigid arm.

3) Where “IS” or “S-IS” arms are specified in hardware sets, if manufacturer does not offer this arm provide a regular arm mount closer in conjunction with a heavy-duty overhead stop equal to a dormakaba 900 Series.

e. Covers:

1) Type: Standard for product selected.

a) Full.

2) Material: Plastic.

3) Finish: Painted.

C. Grades:

1. Closers: Comply with BHMA A156.4, Grade 1.

a. Underwriters Laboratories Compliance:

1) Product Listing: UL (DIR) and ULC for use on fire-resistance-rated doors.

a) UL 228 - Door Closers-Holders, With or Without Integral Smoke Detectors.

D. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.

1. Devices listed with California Department of Forestry and Fire Protection, Office of the State Fire Marshal.

E. Types:

1. Rack-and-pinion, surface-mounted. 1-1/2 inches (38 mm) minimum bore.

F. Options:

1. Delayed action, adjustable with an independent valve.

G. Installation:

1. Mounting: Includes surface mounted installations.
2. Mount closers on non-public side of door and stair side of stair doors unless otherwise noted in hardware sets.
3. At out-swinging exterior doors, mount closer on interior side of door.
4. Provide adapter plates, shim spacers, and blade stop spacers as required by frame and door conditions.
5. Where an overlapping astragal is included on pairs of swinging doors, provide coordinator to ensure door leaves close in proper order.

H. Products:

1. Surface Mounted:

a. 8900.

2.10 PROTECTION PLATES

A. Manufacturers:

1. Trimco: www.trimcohardware.com/#sle.

B. Properties:
   1. Plates:
      a. Kick Plates: Provide along bottom edge of push side of every wood door with closer, except aluminum storefront and glass entry doors, unless otherwise indicated.
         1) Size: 10 inches (254 mm) high by 2 inch (51 mm) less door width (LDW) on push side of door.
      b. Edges: Beveled, on four (4) unless otherwise indicated.

C. Grades: Comply with BHMA A156.6.

D. Material: As indicated for each item by BHMA material and finish designation.
   1. Metal Properties: Stainless steel.
      a. Metal, Standard Duty: Thickness 0.050 inch (1.27 mm), minimum.

E. Installation:
   1. Fasteners: Countersunk screw fasteners

F. Products:

2.11 STOPS AND HOLDERS

A. Manufacturers:
   1. Trimco: www.trimcohardware.com/#sle.

B. General: Provide overhead stop/holder when wall or floor stop is not feasible.

C. Grades:
   1. Door Holders, Wall Bumpers, and Floor Stops: Comply with BHMA A156.16 and Resilient Material Retention Test as described in this standard.

D. Material: Base metal as indicated for each item by BHMA material and finish designation.

E. Types:
   1. Floor Stops: Provide with bumper floor stop.

F. Products:
   1. Floor Stops: 1209HA.

2.12 THRESHOLDS

A. Manufacturers:
   1. National Guard Products, Inc: www.ngpinc.com/#sle.

B. Properties:
   1. Threshold Surface: Fluted horizontal grooves across full width.

C. Grades: Thresholds: Comply with BHMA A156.21.

D. Types: As applicable to project conditions. Provide barrier-free type at every location where specified.
   1. Saddle Thresholds: Without thermal break.

E. Products: As listed in the hardware sets.

2.13 WEATHERSTRIPPING AND GASKETING

A. Manufacturers:
   1. National Guard Products, Inc: www.ngpinc.com/#sle.

B. Properties:
   1. Weatherstripping Air Leakage Performance: Not exceeding 0.3 cfm/sq ft of door opening at 0.3 inches of water pressure differential for single doors, and 0.5 cfm/sq ft of door area at 0.3 inches of water pressure differential for double doors for gasketing other than smoke control, as tested according to ASTM E283/E283M; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.
   2. Adhesive-Backed Perimeter Gasketing: Silicone gasket material applied to frame with self- adhesive.
   3. Rigid, Housed, Perimeter Gasketing: Sponge silicone gasket material held in place by aluminum housing; fastened to frame stop with screws.
   4. Overlapping Astragals for Meeting Stiles: Neoprene strip gasket material held in place by aluminum housing and overlapping when doors are closed; mounted to face of meeting stile with screws; surface mounted to door.
   5. Meeting Astragals for Meeting Stiles: Silicone bulb gasket material held in place by aluminum housing; mounted with screws.
      a. Mounting: Surface mounted on face of each door.
   6. Door Sweeps: Neoprene gasket material held in place by flat aluminum housing or flange; surface mounted to face of door with screws.

C. Grades: Comply with BHMA A156.22.

D. Products:
   1. Meeting Stile Seals: See Door Hardware Schedule.
   2. Door Bottom Seals:
      a. Door Sweeps: See Door Hardware Schedule.

2.14 MISCELLANEOUS ITEMS

A. Manufacturers:
   1. Trimco: www.trimcohardware.com/#sle.

B. Properties:
   1. Coat Hooks: Provide on room side of door, screw fastened.
      a. Material: Brass.

C. Products:
   1. Coat Hooks: 3071

2.15 ELECTRIFIED HARDWARE

A. Manufacturers:
   1. BEST, dormakaba Group: www.bestaccess.com/#sle.
   2. Substitutions: Not permitted.

B. Properties:
   1. Power Supply Units: Manufacturer's standard.
      a. Regulatory Compliance:
         1) United States Compliance:
            a) UL listed for Class II Output.
            b) Comply with UL 294 Standards incorporating enhanced Access Control. communications capabilities.
         2) Canada Compliance:
            a) Comply with ULC S-319 Electronic Access Control Systems.
      b. Enclosures: Lockable NEMA Type 1, with hinged cover and knockouts.
      c. Power: 24 VAC, 10 Amp; field-selectable.
      d. Emergency Release Terminals: Designed to release devices upon activation of fire alarm system.
      e. Auxiliary contacts for remote signaling.
      f. User-selectable time delay from 0 to 4 minutes.
      g. Fire Alarm System Interface: Standard.
         1) Fire alarm terminal with green LED indicating power is available.
      h. Output Distribution Board with indicator LEDs.
      i. On/Off LED power indicator.
   2. Power Transfers: Manufacturer's standard.
      a. Door Loops:
         1) Armored flex conduits 18 inches (450 mm) long.
         2) Capacity: Up to 1/4 inch (6.35 mm) diameter wire bundle.
   3. Wire Harnesses: Of sufficient length, with quick connectors.
      a. Wire Harness End Connection to Power Supply or Junction Box: One end with bare leads.

C. Products:
   1. Power Supplies:
      a. RPSMLR2.
   2. Power Transfers:
      a. EPT-12C.

2.16 KEYS AND CORES

A. Manufacturers:
   1. BEST, dormakaba Group: www.bestaccess.com/#sle.
   2. Substitutions: Not permitted.

B. Properties: Complying with guidelines of BHMA A156.28.
   1. Provide small format interchangeable core.
   2. Provide Patented CORMAX keys and cores.
   3. Provide keying information in compliance with DHI (KSN) standards.
   4. Keying Schedule: Arrange for a keying meeting, with Architect, Owner and hardware supplier, and other involved parties to ensure locksets and locking hardware, are functionally correct and keying complies with project requirements.
   5. Keying: Master keyed.
   6. Include construction keying and control keying with removable core cylinders.
   7. Supply keys in following quantities:
      a. Master Keys: 4 each.
      b. Construction Master Keys: 6 each.
      c. Construction Keys: 15 each.
      d. Construction Control Keys: 2 each.
      e. Control Keys if New System: 2 each.
   8. Provide key collection envelopes, receipt cards, and index cards in quantity suitable to manage number of keys.
   9. Deliver keys with identifying tags to Owner by security shipment direct from manufacturer.
   10. Permanent Keys and Cores: Stamped with applicable key marking for identification. Do not include actual key cuts within visual key control marks or codes. Stamp permanent keys "Do Not Duplicate."
   11. Include installation of permanent cores and return construction cores to hardware supplier. Construction cores and keys to remain property of hardware supplier.

C. Products:
   1. Patented:
      a. CORMAX.

2.17 FINISHES

A. Finishes: Identified in Hardware Sets.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that doors and frames are ready to receive this work; labeled, fire-rated doors and frames are properly installed, and dimensions are as indicated on shop drawings.

B. Correct all defects prior to proceeding with installation.

C. Verify that electric power is available to power operated devices and of correct characteristics.

3.02 INSTALLATION

A. Install hardware in accordance with manufacturer's instructions and applicable codes.

B. Install hardware using the manufacturer's fasteners provided. Drill and tap all screw holes located in metallic materials. Do not use "Riv-Nuts" or similar products.

C. Install hardware on fire-rated doors and frames in accordance with applicable codes and NFPA 80.

D. Install hardware for smoke and draft control doors in accordance with NFPA 105.

E. Use templates provided by hardware item manufacturer.

F. Do not install surface mounted items until application of finishes to substrate are fully completed.

G. Wash down masonry walls and complete painting or staining of doors and frames.

H. Complete finish flooring prior to installation of thresholds.

I. Door Hardware Mounting Heights: Distance from finished floor to center line of hardware item. As indicated in following list; unless noted otherwise in Door Hardware Schedule or on drawings.
   1. For Steel Doors and Frames: Install in compliance with DHI (LOCS) recommendations.
   2. Mounting heights in compliance with ADA Standards:
      a. Locksets: 40-5/16 inch (1024 mm).
      b. Push Plates/Pull Bars: 42 inch (1067 mm).
      c. Deadlocks (Deadbolts): 48 inch (1219 mm).
      d. Exit Devices: 40-5/16 inch (1024 mm).
      e. Door Viewer: 43 inch (1092 mm); standard height 60 inch (1524 mm).

J. Set exterior door thresholds with full-width bead of elastomeric sealant at each point of contact with floor providing a continuous weather seal; anchor thresholds with stainless steel countersunk screws.

K. Include in installation for existing doors and frames any necessary field modification and field preparation of doors and frames for new hardware. Provide necessary fillers, reinforcements, and fasteners for mounting new hardware and to cover existing door and frame preparations.

3.03 FIELD QUALITY CONTROL

A. Perform field inspection and testing under provisions of Section 01 45 00 - Contractor Quality Control.

B. Provide an Architectural Hardware Consultant (AHC) to inspect installation and certify that hardware and installation has been furnished and installed in accordance with manufacturer's instructions and as specified.

3.04 ADJUSTING

A. Adjust hardware for smooth operation.

B. Adjust gasketing for complete, continuous seal; replace if unable to make complete seal.

3.05 CLEANING

A. Clean finished hardware in accordance with manufacturer's written instructions after final adjustments have been made.

B. Clean adjacent surfaces soiled by hardware installation activities.

C. Replace items that cannot be cleaned to manufacturer's level of finish quality at no additional cost.

3.06 PROTECTION

A. Do not permit adjacent work to damage hardware or finish.

Manufacturer List

Code	Name
AB	ABH Manufacturing Inc.
BE	Best Access Systems
BY	By Related Section
DM	Dorma Door Controls
NA	National Guard
PR	BEST Precision Exit Devices
RC	RCI
ST	BEST Hinges and Sliding
TR	Trimco

Option List

Code	Description
1/4-20 SSMS/EA	Stainless Machine Screws w/Expansion Anchors
B4E	Beveled 4 Edges
C	Quick Connect Wiring System
CD	Cylinder Dogging
CSK	Counter Sunk Screw Holes
FL	Fire Exit Hardware
LBR	Less Bottom Rod
MLR	Motorized Latch Retraction
RQE	Request to Exit
SIA	Abrasive Coating
TS	Touchbar Monitoring Switch

Finish List

Code	Description
28	Aluminum Anodized (Clear)
32D	Satin Stainless Steel
626	Satin Chromium Plated
626W	Weatherized Satin Chrome
628	Satin Aluminum, Clear Anodized
630	Satin Stainless Steel
689	Aluminum Painted
AL	Aluminum
BL	Black
US32D	Stainless Steel, Dull

Hardware Sets

Set #1.0

Doors: D01, D02,110

6	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Exit Device	C MLR TS 2203 X 1703A LBR	626W	PR
1	Exit Device	C TS 2201 CD LBR	626W	PR
1	Rim Cylinder	12E-72 PATD	626	BE
1	Mortise Cylinder	1E-74 PATD	626	BE
2	Door Closer	8916 SPA	689	DM
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
2	Floor Stop	1209HA	630	TR
2	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Astragal Set	115NA		NA
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
2	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #1.1

Door: D09

6	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Exit Device	C MLR TS 2203 X 1703A LBR	626W	PR
1	Exit Device	C TS 2201 CD LBR	626W	PR
1	Rim Cylinder	12E-72 PATD	626	BE
1	Mortise Cylinder	1E-74 PATD	626	BE
2	Door Closer	8916 SPA	689	DM
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
2	Floor Stop	1209HA	630	TR
2	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Weatherstrip	160SA Head & Jambs		NA
2	Door Sweep	200NA		NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #2.0

Doors: D04, D05, D06

3	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Exit Device	C MLR TS 2103 X 1703A	626W	PR
1	Rim Cylinder	12E-72 PATD	626	BE
1	Door Closer	8916 SPA	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Floor Stop	1209HA	630	TR
1	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
1	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #2.1

Door: D03

1	Position Switch	9540	BL	RC

Set #3.0

Door: D10

6	Butt Hinges	FBB191 4.5" x 4.5"	32D	ST
2	Pull Plate	1017-3B	32D	TR
2	Push Plate	1001-3	32D	TR
2	Door Closer	8916 FHP	689	DM
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
2	Floor Stop	1209HA	630	TR
1	Gasketing	5050B Head & Jambs		NA

Set #4.0

Door: D11

6	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
2	Flushbolt	3917-12	26D	TR
1	Dust Proof Strike	3910N	26D	TR
1	Storeroom Lockset	45H-7D15N PATD	630	BE
1	Door Closer	8916 S-DS	689	DM
1	Overhead Stop	4420 Series	32D	AB
1	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
1	Astragal	139SP		NA
1	Gasketing	5050B Head & Jambs		NA

Set #5.0

Door: D07

2	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Power Transfer Hinge	CEFBB191-54 4.5" x 4.5"	32D	ST
1	Electromechanical Lock	45HW-7DEU15N PATD C RQE	630	BE
1	Door Closer	8916 S-DS	689	DM
1	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Power Supply	DKPS-2A		RC
1	Gasketing	5050B Head & Jambs		NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #6.0

Door: D08

3	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Storeroom Lockset	45H-7D15N PATD	630	BE
1	Door Closer	8916 S-DS	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Gasketing	5050B Head & Jambs		NA

Set #7.0

Door: D12

3	Hinges	FBB191 4.5" x 4.5"	32D	ST
1	Privacy Set	45H-0L15N	630	BE
1	Overhead Stop	4424	US32D	AB
1	Coat Hook	3071	630	TR
1	Gasketing	5050B Head & Jambs		NA

Set #8.0

Doors: 102, 103, 201, 209

1	Storeroom Lockset	45H-7D15N PATD	630	BE
1	Electric Strike	2364	32D	RC
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Power Supply	DKPS-2A		RC

NOTE: Balance of hardware is existing to remain. Field verify existing conditions. Rework door/frame to receive new hardware.

Set #9.0

Door: 113

1	Electromagnetic Lock	8310 DSS/SCS	28	RC
1	Card Reader	by Owners Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Power Supply	DKPS-2A		RC
1	Infrared Egress Switch	915AFI B	BL	RC

NOTE: Balance of hardware is existing to remain. Field verify existing conditions. Tie magnetic lock to fire alarm panel to release at alarm.

Set #10.0

Door: 01-Fluoride

3	Butt Hinges	FBB191 4.5" x 4.5" NRP	32D	ST
1	Exit Device	FL2108 x 4908A	626W	PR
1	Rim Cylinder	12E-72 PATD	626	BE
1	Door Closer	8916-AFP	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Floor Stop	1209HA	630	TR
1	Gasketing	5050B Head & Jambs		NA

Set #11.0

Door: 02-Fluoride

3	Hinges	FBB191 4.5" x 4.5"	32D	ST
1	Electromechanical Lock	45HW-7DEU15N PATD C RQE	630	BE
1	Door Closer	8916-AFP	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Floor Stop	1209HA	630	TR
1	Power Transfer	EPT-12C	628	PR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	DKPS-2A		RC
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
1	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

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 tapes.
   4. Miscellaneous glazing materials.

1.02 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.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches square.

1.04 INFORMATIONAL SUBMITTALS

A. Product Certificates: For glass.

B. Product test reports.
   1. for tests
   2. performed by a qualified testing agency. For glazing sealants, provide test reports based on testing current sealant formulations within previous 36-month period.

C. Preconstruction adhesion and compatibility test report.

D. Sample warranties.

1.05 QUALITY ASSURANCE

A. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021 to conduct the testing indicated.

1.06 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 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design glazing.

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. Design Snow Loads: As indicated on Drawings.
   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. 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.
   2. 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.
   3. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.02 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 or manufacturer. 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.

2.03 GLASS PRODUCTS

A. 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.

B. Reflective- and Low-E-Coated Vision Glass: ASTM C1376.

2.04 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: Manufacturer's standard spacer material and construction.
   3. Desiccant: Molecular sieve or silica gel, or a blend of both.

2.05 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 804.3 tape, where indicated.
   2. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
   3. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:
   1. AAMA 810.1, Type 1, for glazing applications in which tape acts as primary sealant.
   2. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

2.06 MISCELLANEOUS GLAZING MATERIALS

A. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

B. Setting Blocks:
   1. EPDM with Shore A durometer hardness of 85, plus or minus 5.
   2. Type recommended in writing by sealant or glass manufacturer.

C. Spacers:
   1. Neoprene blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.
   2. Type recommended in writing by sealant or glass manufacturer.

D. Edge Blocks:
   1. EPDM with Shore A durometer hardness per manufacturer's written instructions.
   2. Type recommended in writing by sealant or glass manufacturer.

E. 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.

PART 3 EXECUTION

3.01 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.

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.

3.02 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. Apply heel bead of elastomeric sealant.

F. 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.

G. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.03 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket 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. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

3.04 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.

3.05 MONOLITHIC GLASS SCHEDULE: GL-1

A. Clear Glass Type: Fully tempered float glass.
   1. Minimum Thickness: 6 mm.
   2. Safety glazing required.

3.06 INSULATING GLASS SCHEDULE: GL-2

A. Low-E-Coated, Tinted Insulating Glass Type:
   1. Overall Unit Thickness: 1 inch.
   2. Minimum Thickness of Each Glass Lite: 6 mm.
   3. Outdoor Lite: Tinted fully tempered float glass.
   4. Tint Color: Blue-green.
   5. Interspace Content: Air.
   6. Indoor Lite: Clear fully tempered float glass.
   7. Low-E Coating: Pyrolytic on second surface.
   8. Safety glazing required.

END OF SECTION

SECTION 09 90 00

GENERAL COATING SPECIFICATION

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This Section specifies coating system materials, surface preparations, application, and quality control (QC) requirements.
   2. This Section includes:
      a. All substrates exposed to non-corrosive or moderately corrosive environment.
      b. Atmospheric, weathering exposure, non-corrosive building exposure conditions and piping, equipment, and structures not exposed to immersion services or corrosive headspace (gaseous) exposures, and
      c. internal building surfaces substrates for areas occupied by personnel.
   3. The Contractor is solely responsible for all aspects of QC inspections for the work covered by this Section. The QC inspection personnel and coating manufacturer technical representative (CTR) are provided by the General Contractor at no additional cost to the Owner. Inspections, testing, or other forms of quality checks may be provided by the Construction Manager for quality assurance (QA) checks but in no way relieve the Contractor of sole responsibility for quality and performance of the installed coating system.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 11 80 Environmental Conditions
   2. Section 01 33 00 Submittal Procedures
   3. Section 01 45 00 Contractor Quality Control
   4. Section 01 45 23 Testing and Inspection Services
   5. Section 01 61 45 Area Exposure Designations
   6. Section 01 66 00 Product Storage and Handling
   7. Section 01 99 00 Reference Forms
   8. Section 07 11 13 Bituminous Dampproofing
   9. Section 07 13 26 Self-Adhering Sheet Waterproofing
   10. Section 07 16 00 Cementitious Waterproofing
   11. Section 09 96 00 High Performance Protective Coatings for Wastewater
   12. Section 09 97 00 Potable Water Coatings

1.03 DEFINITIONS

A. Specific coating terminology used in this Section is in accordance with definitions contained in ASTM D16, ASTM D3960, and the following definitions.
   1. Abrasive: Material used for blast cleaning, such as sand, grit or shot.

2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed by compressed air.
3. AMPP: Association for Materials Protection and Performance (Merger of National Association of Corrosion Engineers and Society for Protective Coatings).
4. Anchor Pattern: Profile or texture of prepared surface(s).
5. ANSI: American National Standards Institute.
6. Bug Holes: Cavities or air voids resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.
7. Coating Thickness: The total dry film thickness of primer, intermediate, and/or finish coats.
8. Coating System Applicator (CSA): A generic reference to the specialty subcontractor or subcontractors retained by the Contractor to install the coating systems specified in this Section.
9. Coating System Manufacturer (CSM): Refers to the acceptable coating system manufacturer, abbreviated as the CSM.
10. Coating System Manufacturer's Technical Representative(s) (CTR): Refers to the independent technical representative(s) of the acceptable Coating System Manufacturer and is abbreviated as CTR. This refers to a CSM technical representative and not a sales or marketing representative. The cost of this independent technical representative is the responsibility of the General Contractor.
11. Dew point: Temperature of a given air/water vapor mixture at which condensation starts.
12. Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001 inch). DFT is the thickness of a coating as measured above the substrate.
13. Dry Spray: Dry, flat, probably textured coating surface when spray gun held too far from substrate.
14. Drying Time or curing time: Time interval between application and curing of material before exposure to service conditions.
15. Dry to Recoat: Time interval between application of material and ability to receive next coat.
16. Dry to Touch: Time interval between application of material and ability to touch lightly without damage.
17. Feather Edging: Reducing the thickness of the edge of paint.
18. Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.
19. Field Coat: The application or the completion of application of the coating system after installation of the surface receiving coating at the site of the work.
20. Fish Eyes: Separation or pulling apart of wet film of coating to expose underlying film or substrate.
21. Flash Report: A report by email or text to the Construction Manager and Engineer identifying issues requiring immediate attention and approval.
22. Hold Point: A defined point, specified in this Section, at which work shall be halted for a quality inspection.
23. Holiday: A discontinuity, skip, or void in coating or coating system film that exposes the substrate.
24. Honeycomb: Segregated condition of hardened concrete due to non-consolidation.

25. ICRI: International Concrete Repair Institute.
26. Incompatibility: Inability of a coating to perform well over another coating because of lack of cure of prior coating, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.
27. Laitance: A layer of weak, non-durable concrete containing cement fines that are brought to the surface through bleed water because of concrete finishing and/or over-finishing.
28. LEED: Leadership in Energy and Environmental Design certification program by the US Green Building Council.
29. Mil: 0.001 inch, one thousandth of an inch.
30. Mudcracking: Deep irregular cracks in coating that resemble dried mud caused by non-flexible coatings applied too thickly or built-up in corners.
31. NACE: National Association of Corrosion Engineers to be renamed Association of Materials Performance and Protection or AMPP.
32. NAPF: National Association of Pipe Fabricators.
33. Certified Coatings Inspector: Must be AMPP Certified to Level 3 and have at least 10 years' experience in wastewater coatings inspection.
34. Overspray: Coating spray, particularly such coating that failed to strike the intended surface and ended up on surfaces not to be coated.
35. Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.
36. Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.
37. QA: Quality Assurance
38. QC: Quality Control
39. QCP: Quality Control Person representing the Contractor and responsible for QC Testing, Inspection and associated documentation.
40. Quality Control Testing and Inspection Plan (QCTIP).
41. Repair Mortars: Cementitious, polymer modified cementitious, or polymer-based mortars used to restore concrete or masonry substrates to overall continuous, coatable surfaces by filling voids and excess substrate profile that cannot be hidden by the DFT of the coating system.
42. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-base material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces at typically shallow depths up to 1/4 inch thick.
43. Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.
44. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.
45. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
46. SSPC: The Society for Protective Coatings soon to become part of AMPP.
47. Stripe Coat: A separate coat of paint applied to all weld seems, pits, nuts/bolts/washers and edges by brush. This coat shall be applied prior to full coat application.

48. Saturated Surface Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
49. Tie Coat: An intermediate coat used to bond different types of paint coats. Coatings used to improve the adhesion of a succeeding coat.
50. Touch-Up Painting: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
51. TPC: Technical Practice Committee.
52. Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).
53. Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in a liquid such as water or wastewater at least intermittently if not constantly.
54. Weld Spatter: Beads of metal scattered near seam during welding.
55. Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application. Wet film thickness is measured in mils or thousandths of an inch (0.001 inch) and is abbreviated WFT.

1.04 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, use the last version of the document before it was discontinued.

Reference	Title
ANSI/ASC 29.4 Exhaust Systems	Abrasive Blasting Operations – Ventilation and Safe Practice
ANSI/NSF 61/600	Drinking Water System Components Health Effect
ANSI B74.18	Grading of Certain Abrasive Grain on Coated Abrasive Material
ASTM C1583	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)
ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
ASTM D2200 (SSPC-VIS1)	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ASTM D3359	Standard Test Methods for Rating Adhesion by Tape Test
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

Reference	Title
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings on Metal Substrates Using Portable Adhesion Testers
ASTM 5402	Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
ASTM D6677	Standard Test Method for Evaluating Adhesion By Knife
ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers.
ASTM E337	Standard Test Method for Measuring Humidity With a Psychrometer
ASTM F22	Water Break Test
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2170	Standard Test Method for Measuring Relative Humidity in Concrete Floor Slabs Using Insitu Probes.
FS 595b	Federal Standard Colors
ICRI 310.2	Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
ISO 8502-3 (Part 3)	Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method)
NACE Publication 6D-163	A Manual for Painter Safety
NACE Publication 6G-164 A	Surface Preparation Abrasives for Industrial Maintenance Painting
NACE Standards	National Association of Corrosion Engineers, TPC.
NACE Standard RP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
NAPF 500-03-04	Abrasive Blast Cleaning for Ductile Iron Pipe
NAPF 500-03-05	Abrasive Blast Cleaning for Cast Ductile Iron Fittings
OSHA 1910.144	Safety Color Code for Marking Physical Hazards
OSHA 1915.35	Standards – 29CFR – Painting
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC-PA Guide 1	Guide for Illumination of Industrial Painting Project
SSPC-PA Guide 3	A Guide to Safety in Paint Application
SSPC-PA Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
SSPC-PA Guide 11	Guide for Protecting Corners, Edges, Crevices and Irregular Steel Geometries by Stripe Coating
SSPC-SP 1	Solvent Cleaning
SSPC-SP 2	Hand Tool Cleaning
SSPC-SP 3	Power Tool Cleaning
SSPC-SP 5/NACE #1	White Metal Blast Cleaning

Reference	Title
SSPC-SP 6/NACE #3	Commercial Blast Cleaning
SSPC-SP 7/NACE #4	Brush-Off Blast Cleaning
SSPC-SP 10/NACE#2	Near-White Blast Cleaning
SSPC-SP 11	Power Tool Cleaning to Bare Metal
SSPC SP WJ-1/NACE WJ-1	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Clean to Bare Substrate
SSPC SP WJ-2/NACE WJ-2	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Very Thorough Cleaning
SSPC SP WJ-3/NACE WJ-3	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Thorough Cleaning
SSPC SP WJ-4/NACE WJ-4	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Light Cleaning
SSPC-SP 13/NACE #6	Surface Preparation of Concrete
SSPC-SP 16	Brush-off Blast Cleaning Non-Ferrous Metals
SSPC SP-CAB 1	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Thorough Cleaning
SSPC SP-CAB 2	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Intermediate Cleaning
SSPC SP-CAB 3	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Brush Blast Cleaning
AMPP SP21548	Pressurized Water Cleaning of Concrete and Cementitious Materials- Thorough Cleaning
SSPC-TR2	Wet Abrasive Blast Cleaning
SSPC-TU-3	Overcoating
SSPC-Guide 15	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC V2	Systems and Specifications: Steel Structures Painting Manual, Volume 2
SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
SSPC-VIS 4	Visual Standards (Water-jetting)
SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)
WPCF Manual of Practice No. 17	Paints and Protective Coatings for Wastewater Treatment Facilities. Guide and Paint Application Specifications.
LEED	Leadership in Energy and Environmental Design

1.05 QUALITY ASSURANCE

A. Standardization:

1. Provide materials and supplies that are standard products of CSMs. Provide materials in each coating system from a single CSM.
2. The standard products of CSMs other than those specified may be acceptable when it is demonstrated to the Engineer that they are equal in generic resin type, composition, durability, range of film thickness, and usefulness, for the purpose intended. Requests for consideration of CSMs other than those specified in this Section will be considered, provided the following minimum conditions are met.
    a. The proposed coating system uses an equal or greater number of separate coats to achieve the required total DFT.
    b. The proposed coating system uses coatings of the same generic type as that specified including curing agent type.

c. Include information listed in paragraph 1.07, demonstrating that the proposed CSM's product is equal to the specified coating system.

d. Provide a list of Contractor and CSM references for the proposed product in similar situations where the coating of the same generic type has been applied. Include the project name, city, state, owner, phone number of owner; coating system reference and number from this Section 09 90 00; type of facility in which it was used, generic coating type, and year coating was applied.

e. Alternate coating systems submitted by the Contractor must be approved by the Engineer. There is no guarantee that alternate systems will be approved, and this is left exclusively up to the discretion of the Engineer. At least 3 competitive products have been provided in this Specification. The Contractor is encouraged to submit one of the specified coating systems.

f. At any time when there is conflict between the CSM's product data and the COAT SPEC requirements regarding surface preparation, material application, or any other coating details, the more stringent requirements will take precedent.

B. Shop and Field Contractors Quality Control Requirements:

1. Prior to any work, hold a pre-construction meeting with the coating subcontractor and coating system manufacturer's technical representatives (CTR) to review the scope of work, the accepted submittals and any comments, and review all surface preparation, application, curing, mixing, storage, and overall QC and testing requirements. Provide a minimum of 48 hours' notice to the Engineer and Owner in case they desire to attend the meeting.
2. The Contractor is solely responsible for the workmanship and quality of the coating system installation by the Contactor's CSA. Inspections by the Construction Manager, the Engineer, the Owner, or the CTR will not relieve or limit the Contractor's responsibilities for the quality of the coating system.
3. Conform to requirements of this specification and the standards referenced in this Section. Changes in the coating system installation requirements will be allowed only with the written acceptance by the Engineer and CSM before work commences.
4. Only personnel who are trained by the CTR specifically for this contract or who are approved by the CSM specifically for this contract shall be allowed to perform the coating system installation specified in this Section. The CTR to verify in writing that the Contractor's personnel installing the coating systems covered by this Section have the appropriate training and/or experience to properly perform the coating systems work.
5. Provide a Quality Control Person (QCP) who is a certified NACE, SSPC, or AAMP Coatings Inspector with at least 5 years of experience inspecting coating work similar to the work covered by this Section. The QCP to perform all QC inspection testing and inspection tasks while fully documenting all efforts required by these specifications and/or additional CSM's requirements.
6. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
7. For repairs, I provide the same products, or products recommended by the CSM, as used for the original coating.
8. Identify the points of access for inspection by the Owner, Engineer and/or Construction Manager. Provide ventilation, ingress and egress, and other means necessary for the Engineer, Owner, or Construction Manager's personnel to safely access the work areas.

9. Contractor's CSA to conduct the work so that the coating system is installed as specified and inspect the work continually to ensure that the coating system is installed as specified. Correct coating system work that does not conform to the specifications or is otherwise not acceptable to the as-specified requirements at no additional cost to the Owner.
10. Provide full time inspection with trained and certified quality control (QC) inspectors performing all QC procedures as the coating work proceeds in accordance with the requirements of this section. Minimum qualifications for QC inspectors on concrete projects is AMPP-CCI Level 1 with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified CCI Level 2 Concrete Coatings Inspector. On non-concrete related project, the minimum QC inspector is AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience. An AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience may be acceptable providing the AMPP Basic, AMPP Certified and AMPP Senior coating inspectors can each can show verifiable proof of performing inspection successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.
11. The Contractor's QC personnel to measure DFT of metal surfaces as per SSPC-PA2. Take measurements as often as necessary to ensure the DFT requirements of the specification are met. Measure DFT of metallic surfaces using Type II Magnetic (Ferrous) and Type II Eddy Current Non-Ferrous) Dry Film Thickness gauges. Use only gauges calibrated within 1 year of use. Perform testing of DFT on concrete substrates as per SSPC-PA9 using Ultrasonic DFT gauges or another suitable method (e.g., Calculating material usage vs square feet coverage) to ensure DFT requirements are met.
12. Contractor/CSA to submit for approval a QCTIP for the work covered by this Section (see 00 97 00A Inspection Check List). List all tests and inspection tasks in the QCTIP including referenced and applicable standards to be conducted and the frequency in which these tests or tasks will be performed. This frequency can be addressed for certain tests such as air and substrate temperature or dew point on an hourly per shift basis. Or this frequency can be addressed on a per number of square feet basis for tests and tasks such as wet and DFT tests or adhesion tests. Include in the QCTIP a written record which identified when (time and date) work not conforming to the specification requirements is identified, a written record of the proposed corrective actions for such non-conforming work and a record of when that action was performed (time and date). Describe all corrective action for non-conforming work in detail with referenced digital photographs taken of the re-work for subsequent review by the Owner's representative.

13. Complete the Coating System Quality Control Checklist, Form 09 90 00-A, included in Section 09 90 00 –Part 4 for coating system installations. Follow the sequential steps required for proper coating system installation as specified and as listed in the Coating System Quality Control Checklist. For each portion of the work, install the coating system, document all QC measures performed, and complete sign-offs as specified prior to proceeding with the next step. After completing each step as indicated on the Coating System Quality Control Checklist, sign the checklist indicating that the work has been installed and inspected as specified and attach a final copy of all individual QC checks or test results as applicable and required.
14. Submit a daily QC inspection report from the QCP that describes and documents all QC tests and inspection tasks performed including frequency of performance and test results (including test data) and referenced standard followed for each shift the CSA works. Submit these reports on the morning of the following day the work was performed to the Construction Manager. Include with the daily QC report a written account of all non-conforming work, subsequent corrective measures and annotated digital photographs. Submit a standard inspection form to be used for these reports for review by the Engineer. CSA's QC Inspector to use approved inspection report forms to record all QC inspection and testing throughout the performance of the coating work.

C. Quality Control Hold Points:
   1. The Contractor's QCP to conduct QC inspections of the coating work as it proceeds to meet all specified quality requirements. In addition, conduct inspection at Hold Points during the coating system installation and record the results on Form 09 90 00-A. Coordinate Hold Points with the CTR, Engineer and Construction Manager so they Construction Manager or Engineer may observe the Quality Control inspections on a scheduled basis. Provide the Construction Manager or Engineer a minimum of 1 days' notice prior to conducting Hold Point Inspections. The Hold Points shall be as follows:
      a. Environment and Site Conditions. Prior to commencing an activity associated with coating system installation, measure and record ambient air temperature and humidity as well as other conditions such as proper protective measures for surfaces not to be coated and safety requirements for personnel. Confirm the weather and/or environmental conditions within the structure comply with the requirements specified by the CSM.
      b. Conditions Prior to Surface Preparation. Prior to commencing surface preparation, perform cleaning to remove all oil, grease, dirt, soluble salts, and all other foreign contaminants from the surface.
      c. Monitoring of Surface Preparation. Spot check degree of cleanliness, surface profile, and surface pH testing, as required. Confirm compressed air used for surface preparation or blow down cleaning is free from oil and moisture.
      d. Post Surface Preparation. Upon completion of the surface preparation, measure and inspect for proper degree of cleanliness and surface profile as specified in this Section 09 90 00 and in the CSM's written instructions.
   2. After surface preparation and prior to the application of primer and coatings the surfaces the CSA must ensure that any remaining dust meets the acceptable level of the specification requirements.
      a. Monitoring of Coatings Application. Inspect, measure, and record the WFT and general film quality (visual inspection) for lack of runs, sags, pinholes, holidays, etc. as the application work proceeds.

b. Post Application Inspection. Identify defects in application work including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems as may be observed.

c. Post Cure Evaluation. Measure and inspect the overall DFT. Conduct a DFT survey, and perform adhesion testing, holiday detection, or cure testing as required based on the type of project and the specific requirements in this Section 09 90 00 and/or in the CSM's written instructions.

d. Follow-up to Corrective Actions and Final Inspection. Measure and reinspect corrective coating work performed to repair defects identified at prior Hold Points. Include final visual inspection along with follow-up tests such as holiday detection, adhesion tests, and DFT surveys.

D. Responsibilities of the CTR:

1. General:

a. Provide the services of the CTR to be on site to routinely verify in writing that the application personnel have successfully performed representative portions of the surface preparation, filler/surface application, coating system application, and QC Inspection in accordance with this Section 09 90 00. Include testing or witnessing the contractors testing for the required degree of cleanliness, surface pH for concrete substrates, surface profile of substrates, proper mixing of coating materials, application (including checking the wet and DFT of the coating systems), proper cure of the coating systems, and proper treatment of coating systems at terminations, transitions, and joints and cracks in substrates. These inspections are not expected to be full-time, but rather to assure that inspections by the CTR are performed on representative portions of all major steps of the coating work to ensure the CSM approves those representative portions of the work to be in compliance with the CSM's recommendations and instructions. This inspection is in addition to the inspection performed by the Contractor in accordance with paragraph 1.05C of this section. The CTR shall provide a reasonable level of oversight of the contractor's QC processes to be representative of key steps in the work, at their discretion, to provide a final sign-off certification that the CSM's products have been properly installed.

2. Coating System Inspection:

a. The CTR shall verify representative steps of the coating work are performed properly per the manufacturer's instructions; the CTR shall coordinate and confirm the planned inspections by the Contractor's QCP are being performed per the QCTIP to assure quality of the work meets the requirements of both these specifications and any additional manufacturer's requirements; and the CTR shall verify or witness the contractors QC processes of the following QC steps at their discretion:

1) Inspect ambient conditions during various coating system installation at hold points for conformance with the specified requirements.

2) Inspect the surface preparation of the substrates where the coating system will terminate or will be applied for conformance to the specified application criteria.

3) Inspect preparation and application of coating detail treatment (for example, terminations at joints, metal embedments in concrete, and other terminations at different substrates).

4) Inspect application of the filler/surface materials for concrete and masonry substrates.
5) Inspect application of the primers and finish coats including WFT and DFT of the coatings.
6) Inspect coating systems for cure.
7) Review adhesion testing of the cured coating systems for conformance to specified criteria.
8) Inspect and record representative localized repairs made to discontinuities identified via continuity testing.
9) Conduct a final review of completed coating system installation for conformance to the specifications.
10) CTR to prepare and submit a site visit report following each site visit that documents the acceptability of the coating work in accordance with the CSM's recommendations.

3. Final Report:
   a. Upon completion of coating work for the project, the CTR shall prepare a letter summarizing the inspection findings and shall attach the site visit reports required in 1.05 D.2. a.10. Include a statement that the completed work was performed in accordance with the requirements of this Section 09 90 00 and the CSM's recommendations based on the inspections performed by the CTR.

1.06 DELIVERY AND STORAGE

A. General:
1. Procedures: In accordance with Section 01 66 00.
2. Deliver materials to the job site in their original, unopened containers. Properly label each container P. Handle and store materials to prevent damage to or loss of label, meeting the project requirements or the CSM's if more stringent.
3. Include the following information on material container labels.:
   a. Name or title of product
   b. CSM's batch number
   c. CSM's name
   d. Generic type of material
   e. Application and mixing instructions
   f. Hazardous material identification label
   g. Shelf-life expiration date
4. Store materials in enclosed structures protected from weather and excessive heat or cold in accordance with the CSM's recommendations. Store flammable materials in accordance with state and local requirements.
5. Clearly mark containers indicating personnel safety hazards associated with the use of or exposure to the materials.
6. Provide Safety Data Sheets (SDS) for each material to the Construction Manager.
7. Store and dispose of hazardous waste including waste solvents and coatings, according to federal, state and local requirements.

1.07 SUBMITTALS:

A. Action Submittals:

1. Provide in accordance with Section 01 33 00:

a. A copy of this specification section, with addendum updates included, and referenced and applicable sections, with addendum updates included, with each paragraph check-marked (☑) to indicate specification compliance or marked to indicate requested deviations from specification requirements or those parts which are to be provided by the Contractor or others. Check marks denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph, and provide a detailed explanation of the reasons for requesting the deviation. Engineer is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined signifies compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections along with justification(s) for requested deviations to the specification requirements is cause for rejection of the entire submittal and no further submittal material will be reviewed.

b. CSM's current printed recommendations and product data sheets for coating systems including:

1) VOC data
2) Surface preparation recommendations
3) Primer type, where required
4) Maximum dry and wet film mil thickness per coat
5) Minimum and maximum curing time between coats, including atmospheric conditions limitations for each (temperature, dewpoint difference from temperature, etc.)
6) Curing time before exposure to elements
7) Thinner to be used with each coating
8) Ventilation requirements
9) Minimum atmospheric conditions during which the paint shall be applied
10) Allowable application methods
11) Maximum allowable moisture content
12) Maximum shelf life

c. Affidavits signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements.

d. Safety Data Sheets (SDS) for materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.

e. List of cleaning and thinner solutions allowed by the CSMs.

f. Storage requirements including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.

g. CSM's detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including, but not limited to, pipe penetrations, metal embedments, and other terminations to be determined from the contract drawings. Include detailed treatment for coating system at joints/terminations in concrete and concrete masonry unit assemblies.

h. CSM's detailed maximum chloride level tolerance for all coatings to be applied on metallic surfaces.

i. Provide a minimum of 5 project references each for the Contractor and CSA including contact name, address, and telephone number where similar coating work has been performed by their companies in the past 5 years.

j. The QCITP as specified in Article 1.05 D 2 and including all pertinent QC requirements covered in the Quality Control Table 09 90 00 – 1 found under Part 4 of this Section. Include:

   1) the QC Inspection Forms

   2) A list of who is responsible for performing and documenting all QC tests and inspection tasks.

k. Shop primer product data sheet and letter stating that shop primer is compatible with the field applied topcoats for all equipment on other items.

l. A daily QC inspection report from the QCP that documents all QC tests and inspections performed and their results for each day of the work. Document all non-compliant work for coating repair. Coordinate the report with the QCTIP provided per 1.05 C.1. Deliver daily QC report electronically to the Construction Manager and Engineer the morning of the following day.

m. Submit a Flash Report (see definitions section for Flash Report definition) from the QCP immediately identifying any items or issues that require immediate attention to the project Engineer

n. Letter from CTR confirming that Contractor's personnel to perform coating work have been trained or have appropriate experience to perform the work covered by this Section.

o. Resume of the Contractor's QCP responsible for performing the QC Testing and Inspection tasks delineated in the Contractor's Inspection and Testing Plan.

B. Informational Submittals:

1. Procedures: Section 01 33 00.
2. Prior to application of coatings, submit letter(s) from the CTR(s) identifying the application personnel who have satisfactorily completed training as specified in Article 1.05 or a letter from the CSM stating that personnel who shall perform the work are approved by the CSM without need for further or additional training.
3. Submit reports specified in Article 1.05 while the work is underway.

C. Closeout Submittals:

1. Procedures: Section 01 33 00
2. Submit the Coating System Quality Control Checklists using Form 09 90 00-A, for the coating work.

D. Product substitution requests:
   1. Refer to the General Conditions and/or General Requirements for substitution requests procedures for materials or requests to substitute other specification requirements, which are handled differently than the normal project submittal procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Notwithstanding the listing of product names in this Section 09 90 00, provide affidavits, signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements. See Section 1.05 for detailed QC requirements required by the contractor. Do not apply coatings to a surface until the specified affidavits have been submitted, reviewed and accepted. Failure to comply with this requirement is cause for rejection and removal of such materials from the site.
   2. The following list specifies the material requirements for coating systems. Coating systems are categorized by generic name followed by an identifying abbreviation. If an abbreviation has a suffix number, it is for identifying subgroups within the coating system.

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD

Coating System	CSM	First Coat(s)	Finish Coat(s)
Epoxy Coatings			
E-1	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890	Carboguard 890
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC	Macropoxy 646 FC
	Tnemec	Series V69	Series V69
E-1-G	AkzoNobel	Intergard 251HS	Interseal 670HS
	Carboline	Carboguard 890	Carboguard 890
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC	Macropoxy 646 FC
	Tnemec	Series V69	Series V69
E-2	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890 series	Carboguard 890 series
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Dura-Plate 235	Dura-Plate 235
	Tnemec	Series V69	Series V69
E-2-C	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890 series	Carboguard 890 series

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD				
	PPG	Amercoat 253		Amercoat 253
	Sherwin Williams	Tank Clad HS		Tank Clad HS
	Tnemec	Series 104		Series 104
E-3	AkzoNobel	Interseal 670HS		Interseal 670HS
	Carboline	Carboguard 890 series		Carboguard 890 series
	PPG	Amerlock 2/400 Series		Amerlock 2/400 Series
	Sherwin Williams	Dura-Plate 235		Dura-Plate 235
	Tnemec	Series V69		Series V69
E-4	AkzoNobel	Interseal 670HS		Interseal 670HS
	Carboline	Carboguard 890		Carboguard 890
	PPG	Amerlock 2/400 Series		Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC		Macropoxy 646 FC
	Tnemec	Series V69		Series V69
E-5	AkzoNobel	Interseal 670HS		Interseal 670HS
	Carboline	Carboguard 890 series		Carboguard 890 series
	PPG	Amerlock 2/400 Series		Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC		Macropoxy 646 FC
	Tnemec	Series V69		Series V69
Epoxy Polyurethane				
WBPU-1	Carboline	NA		NA
	Benjamine Moore	Stays Clear Acrylic WB Polyurethane		Stays Clear Acrylic WB Polyurethane
	PPG	DEFT Acrylic WB Polyurethane		DEFT WB Acrylic Urethane
	Sherwin Williams	Minwax Polycrylic WB Polyurethane		Minwax Polycrylic WB Urethane
Elastomeric Acrylic Coatings				
ELA-1	Carboline	Flexxide Elastomer		Flexxide Elastomer
	PPG	Seal Grip 17-921 XI Series		Perma-Crete Pitt-Flex 4-110XI (interior/exterior elastomeric coating)
	Sherwin Williams	Loxon XP or Loxon Concrete & Masonry Primer		Loxon XP
	Tnemec	Series 156		Series 156
Coating System	**CSM**	**First Coat(s)**	**Second Coat(s)**	**Finish Coat**
Epoxy Polyurethane				
EU-1	AkzoNobel	Interzinc 52 Series	Intergard 251HS	Interthane 990 Series
	PPG	Amercoat 68 HS	Amerlock 2/400 Series	Pithane Ultra
	Carboline	Carbozinc 859 series	Carboguard 890	Carbothane 134 series
	Sherwin Williams	Galvapac 1K Zinc	Macropoxy 646FC	Hi Solids Polyurethane 250
	Tnemec	Tneme-Zinc 90G-1K97	Series V69	Series 1094

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD

Flooring Systems				
EFL-1	PPG	PPG Flooring 912LV – 8-10 mils	PPG Novaguard 5041 –12-15 Mils with 20/40 Mesh Aggregate Broadcast	PPG Novaguard 5041 – 12-15 Mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3741 – 12-15 Mils with 20/40 Mesh Aggregate Broadcast	Resufloor 3741 – 12-15 mils
	Tnemec	Chemtread 239 – 8-10 Mils	Chemtread 239 – 12-15 mils with 50/70 Mesh Aggregate Broadcast	Tneme-Glaze 282 – 12-15 Mils
EFL-2	PPG	PPG Flooring 912LV – 8-10 mils	PPG Flooring 610SL –12-15 mils with 20/40 Mesh Aggregate Broadcast	PPG Flooring 610SL – 12-15 mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3746 – 12-15 mils with 20/40 Mesh Aggregate Broadcast	Resufloor 3746 – 12-15 mils
	Tnemec	Power-Tread 237-8-10 mils	Power-Tread 237- 12-15 mils with 50/70 Mesh Aggregate Broadcast	Tneme-Glaze 280 –12-15 Mils
EFL-3	PPG	PPG Flooring 912LV – 8-10 mils	PPG Flooring 610SL –12-15 mils with 20/40 Mesh Aggregate Broadcast	PPG Flooring 688 – 9.6-12 mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3746 – 12-15 mils with 20/40 Mesh Aggregate Broadcast	Resutile HTS 100 – 3-4 mils
	Tnemec	Power-Tread 237-8-10 mils	Power-Tread 237- 12-15 mils with 50/70 Mesh Aggregate Broadcast	Everthane 248 2-3 mils
Coating System	**CSM**	**First Coat(s)**		**Finish Coat(s)**
EU-1-FRP	AkzoNobel	Interseal 670HS		Interthane 990 Series
	PPG	Amercoat 2/400 Series		Pithane Ultra
	Carboline	Carboguard 890		Carbothane 134 series
	Sherwin Williams	Macropoxy 646FC		Hi Solids Polyurethane 250
	Tnemec	Series V69		Series 1095
Grease				
G	Texaco	N/A		Rust Inhibitive Grease
	Chevron	N/A		E.P. Roller Grease
High Heat				
	AkzoNobel	Interbond 2340UPC		Interbond 2340UPC
	PPG	Amerlock 2/400GF		Amerlock 2/400GF
	Carboline	Carbozinc 11 series		Thermaline 4000

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD			
HH-1 ((Various silicone & epoxy hybrid products up to 400F)	Sherwin Williams	Hi Temp Heat Flex 1000	Hi Temp Heat Flex 1000
HH-2 (TMIC – Titanium Modified Inorganic Co-Polymer up to 1200F)	AkzoNobel	Interbond 1202UPC	Interbond 1202UPC
	PPG	Hi-Temp 1027 Series	Hi-Temp 1027 Series
	Carboline	Thermaline Heat Shield	Thermaline Heat Shield
	Sherwin Williams	Heat Flex High Temp 1200	Heat Flex High Temp 1200
Latex Acrylic			
L-1	Benjamin Moore	SuperKote 3000 Primer	Corotech V331 Acrylic
	Carboline	Sanitile 120	Carbocrylic 3359 MC
	PPG	Pitt-Tech Plus 4020 PF	Pitt-Tech Plus 4216
	Sherwin Williams	Loxon Acrylic Primer	Sher-Cryl HPA
	Tnemec	Series 1028 or 1029	Series 1028 or 1029
L-2	Benjamin Moore	Series 110 Stix Primer	Corotech V331 DTM Acrylic
	Carboline	Sanitile 120	Carbocrylic 3359 MC
	PPG	Pitt-Tech Plus 4020 PF	Pitt-Tech Plus 4216
	Sherwin Williams	Pro-Cryl Primer	Sher-Cryl HPA
	Tnemec	Series 1028 or 1029	Series 1028 or 1029
L-3	Benjamin Moore	Corotech V331 DTM Acrylic	Corotech V331 DTM Acrylic
	Carboline	Carbocrylic 3359 DTMC	Carbocrylic 3359 DTMC
	PPG	Pitt-Tech Plus 4020 PF	Pitt-Tech Plus 4216
	Sherwin Williams	Pro-cryl Primer	Sher-Cryl HPA
	Tnemec	Series 1028 or 1029	Series 1028 or 1029
L-4	Benjamin Moore	Series 110 Stix Primer	Corotech V331 DTM Acrylic
	Carboline	Sanitile 120	Carbocrylic 3359 MC
	PPG	Pitt-Tech Plus 4020 PF	Pitt-Tech Plus 4216
	Sherwin Williams	Acrylic Wall & Wood Primer	Sher-Cryl HPA
	Tnemec	Series 1028 or 1029	Series 1028 or 1029
Miscellaneous			
M-1	Carboline	Carbowrap Tape series Paste	Carbowrap series Petrolatum Tape
	Denso	Denso Paste	Densyl Tape
	Trenton	Waxtape Primer	#1 Wax Tape
M-2	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carbomastic 615	Carbomastic 615

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD			
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Tank Clad HS	Tank Clad HS
	Tnemec	Series 135	Series 135
Penetrating Stain			
S-1	Sherwin Williams	H&C Color Top	H&C Color Top
	PPG	NA	Permacrete 4-4210XI Series
	Tnemec	Series 617	Series 617
S-2	Curecrete Chemical Company	N/A	Ashford Formula
	Sherwin Williams	N/A	Conflex 7% Silane Sealer
	PPG	Permacrete 4-6100C	Permacrete 4-6100C
	Tnemec	N/A	Series 633 Prime-A-Pell H2O
S-3	Sherwin Williams	N/A	Conflex 7% Siloxane
	PPG	Permacrete 4-6100C	Permacrete 4-6100C
	Tnemec	N/A	Series 633 Prime-A-Pell H2O
Anti-Graffiti Silicon			
AG-1	CSL	Si Coat 532 Clear	Coat 532 Clear
	ICD Performance Coatings	PerformaSil 200	PerformaSil 200
	Prosoco	Blockguard WB6	Blockguard WB6

**See CSM's Product Data Sheets for acceptable thinners for VOC compliance or do not thin.*

PART 3 EXECUTION

3.01 COATINGS

A. General:

1. Do not use coating products until the Engineer, Construction Manager, Owner, or Owner's Representative has accepted the affidavits specified in paragraphs 1.07 and 2.01 and the CTR has trained the Contractor and CSA in the surface preparation, mixing, and application of each coating system.
2. Erect and maintain protective enclosures as stipulated per SSPC-Guide 6 Guide for Containing Debris Generated During Paint Removal Operations.
3. Only use primers accepted as part of the coating submittal for the specific project components, including for shop applied primers.

B. Shop and Field Coats:

1. Shop Applied Prime Coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Use only shop-applied primers which have been identified and accepted as part of the coating submittal. It must be compatible with the specified coating system and applied at the minimum DFT recommended by the CSM. Provide data sheets identifying the shop primer as a Submitted for Approval as required in Article 1.07. All requirements for surface preparation, inspections and testing, and documentation apply to shop applied primers. Perform adhesion tests on the shop primer as specified in paragraph 3.01 B.3. Adhesion Confirmation. Remove damaged, deteriorated and poorly applied shop coatings that do not meet the requirements of this Section 09 90 00 and the surfaces recoated. If the shop primer coat meets the requirements of this Section 09 90 00, the field coating may consist of touching up the shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity.
2. Field Coats: Apply field coats consisting of one or more prime coats and one or more finish coats to build up the coating to the specified coating system DFT. Unless otherwise specified, do not apply finish coats until other work in the area is complete and previous coats have been inspected.
3. Adhesion Confirmation: Perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that (1) the shop applied prime coat adheres to the substrate and (2) the specified field coatings adhere to the shop applied coat. Test results showing an adhesion rating of 4A or better on surfaces are required for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 4B or better on other surfaces are acceptable for coating thicknesses less than 5 mils.
4. Test compatibility of coatings applied over existing coatings of different generic chemistry for compatibility through test patches applied and provided time for cure. After suitable cure time as per the CSM, perform adhesion testing as per 3.01.B.3 prior to proceeding.

C. Application Location Requirements:

1. Equipment, non-immersed, non-corrosive atmosphere: For items of equipment, or parts of equipment that are not immersed in service, shop prime and then finish coat in the field after installation with the specified or acceptable color. If the shop primer requires top coating within a specified period, finish coat the equipment in the shop and then touch-up paint after installation in the field. If equipment removal and reinstallation is required for the project, touch-up coating the field following reinstallation. [For equipment exposed to corrosive atmosphere or immersion, refer to specification [09 96 00] [09 97 00].]
2. For equipment that is partially or totally immersed, exposed to corrosive atmosphere, or chemical secondary containment, refer to specification 09 96 00 High Performance Coatings.
3. For equipment in potable water applications requiring NSF/ANSI/CAN 61/600 certified coatings refer to specification 09 97 00 Potable Water Coatings

3.02 PREPARATION

A. General:

1. Prepare each type of surface in accordance with the specific requirements of each coating specification sheet (COATSPEC) and the following. In the event of a conflict, the more stringent requirements shall take precedence.
2. Clean and dry surfaces to be coated. Before applying coating or surface treatments, remove oil, grease, dirt, rust, mill scale, old, weathered coatings, and other foreign substances. Remove oil and grease before mechanical cleaning. Where testing reveals chloride contamination, remove chlorides prior to blast cleaning or other mechanical surface preparation methods. Where mechanical cleaning is accomplished by blast cleaning, wash, grade, and free the abrasive from contaminants that might interfere with the adhesion of the coatings. Use air for blast cleaning that is free of oil and moisture so as not to cause detrimental contamination of the surfaces to be coated.
3. Protect all surfaces and equipment not to be coated from dust and overspray. Schedule cleaning and coating so that dust and spray from the cleaning process shall not fall on wet, newly coated surfaces. Remove or mask hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces prior to surface preparation and coating operations. Reinstall removed items following completion of coating. Disconnect and move equipment adjacent to walls to permit cleaning and coating of equipment and walls. Replace and reconnect items following coating.

B. Blast Cleaning:

1. Meet the following requirements for abrasive blast cleaning:
    a. Do not reuse blast abrasive. Do not use silica sand for the blast abrasive. Use blast abrasive media which provides the most efficient cutting action to achieve the profile and degree of cleanliness specified.
    b. Filter compressed air used for blast cleaning and ensure it contains no condensed water or oil. Clean moisture traps at least once every 4 hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment.
    c. Install oil separators just downstream of compressor discharge valves and at the discharge of the blast pot discharges. Check and clean oil separators on the same frequency as the moisture traps as defined above.
    d. Regulators, gauges, filters, and separators must be in use on compressor air lines to blasting nozzles at all times during this work.
    e. Install an air dryer or desiccant filter drying unit which dries the compressed air prior to blast pot connections. Use and maintain the dryer for the duration of surface preparation work.
    f. Use abrasive blast nozzles of the venturi or other high velocity type supplied with a minimum of 100 pounds per square in gauge (psig) air pressure and sufficient volume to obtain the blast cleaning production rates and cleanliness specified.
    g. Provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.

h. If, between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, reclean the surface by water jetting and/or abrasive blast cleaning until the specified degree of cleanliness is reclaimed.

i. Protect mechanical, electrical, and other equipment adjacent to and surrounding the work area from dusts, overspray and general damage.

C. Solvent Cleaning:

1. Use emulsifying type solvent wash, solvent wipe, or cleaners , including but not limited to those used for surface preparation in accordance with SSPC-SP 1 Solvent Cleaning, which emit no more than [340 g/l VOCs for AIM regions], [250 g/l for CARB regions], [100 g/l for SCAQMD regions], contains no phosphates, is biodegradable and is compatible with the specified primer.
2. Use clean white cloths and clean fluids in solvent cleaning.

D. Metallic Surfaces:

1. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the Society for Protective Coatings (SSPC) and NACE International (NACE) specified for each coating system. See Coat Spec for each coating system in this Section 09 90 00. The profile depth of the surface to be coated shall be in accordance with the COATSPEC requirements in this Section measured by Method C of ASTM D4417. Select blast particle size to produce the specified surface profile. Use solvent in solvent cleaning operations as recommended by the CSM.
2. Take the following steps if soluble chloride contamination is suspected or is possible/plausible. Following initial blast cleaning of steel substrates, test for the presence of soluble chlorides using the retrieval and analysis method designated as Method 4.2.2. Adhesively Bonded Latex Patch or Cell as described in SSPC-TG15. Test accordance with ISO 8502-6/8502-9 at the rate of 4 tests per 1,000 sq. ft. of steel surface area to be coated, but no less than a total of 4 tests per component. The target threshold or tolerance conductivity level for soluble chloride contamination shall be approved in writing by the CSM's CTR for each product that is part of the application.
3. Prepare metallic surfaces based upon comparison with SSPC-VIS1-89 (ASTM D2200) and as described in the COATSPEC for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection, on the first day of cleaning operations, provide abrasive blast metal reference panels meeting the standards specified for acceptance by the Construction Manager. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels accepted by the Construction Manager as meeting the requirements of the specifications shall be initialed by the Contractor and the Construction Manager and coated with a clear non-yellowing finish. Provide a reference panel for each type of abrasive blasting to be used as the comparison standard throughout the project.
4. Blast cleaning requirements for steel, ductile iron, and stainless steel substrates are as follows:
    a. Prepare steel piping in accordance with SSPC-SP 6/NACE#3 (Commercial Blast Cleaning) and prime before installation. Prepare ductile iron piping surfaces including fittings in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05.

b. Abrasive blast clean stainless steel surfaces in accordance with SSPC-SP 16 to leave a clean uniform appearance with a minimum uniform surface profile of 1.5 to 2.5 mils, unless required to be greater by the CSM.

c. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products or embedded abrasive from substrate by vacuum-cleaning prior to coating application. Blow down cleaning with compressed air is not permitted.

d. Prevent contamination of the surface after blasting from worker's fingerprints, deleterious substances on workers' clothing, or from atmospheric conditions.

e. Continuously monitor and maintain ambient environmental conditions in the enclosure to ensure the degree of cleanliness is held and no "rust back" occurs prior to coating material application.

5. Abrasive blast clean galvanized steel surfaces per SSPC SP 16 to produce a minimum surface profile of 1.0 to 1.5-mil profile and to remove all corrosion products. Caution–follow CSM's specific recommendations for surface prep, including abrasive blast cleaning.

6. Cleaning of soluble salt contamination shall be as follows:

a. and analysis method designated as Method 4.2.2. Adhesively Bonded Latex Patch or Cell as described in SSPC-TG15 (2013). Testing shall be in accordance with ISO 8502-6/8502-9 at the rate of 4 tests per 1,000 sq. ft. of steel surface area to be coated. The Contractor shall clean and prepare the surfaces to remove the soluble salts until acceptable test levels for conductivity are shown by further testing as required above.

b. b. Allowable concentrations of soluble chlorides shall be at the direction of the CSM for each individual product to be used

c. c. Cleaning for decontamination shall utilize a steam generator ("Jenny") capable of producing steam/hot water temperature of 150 degrees F minimum. Hot water pressure washing at 150 degrees F can also be utilized using clean, fresh, potable water only. The steam/hot water shall be applied using a lance with a nozzle providing a fan shaped spray pattern. The recommended discharge temperature is 140 degrees F for safety reasons. Contractor shall take appropriate safety precautions during use of hot water.

d. d. Steam/hot water shall be applied in a minimum of 2 passes over surfaces to be cleaned. Horizontal members on substrates shall be cleaned from end to end continuously and from top to bottom as this horizontal progression continues. Vertical pipes or substrates shall be cleaned around the circumference from top to bottom (crown to invert) to ensure complete solubility and rinsing of contaminants from top to bottom. As this cleaning proceeds, the surfaces of the steel shall be scrubbed using stiff bristle brushes.

e. e. Once completed, this cleaning shall be followed by repeated thorough rinsing. Rinsing can be accomplished using pressure water washing using unheated potable water. Once decontamination cleaning has been performed over a representative (small) area, the cleaned substrate shall be tested for soluble salt concentrations to ensure that the pattern and extent of cleaning shall be adequate. Testing shall be performed as defined above in 3.02 D.6.a.

E. Concrete Surfaces:

1. Inspect concrete surfaces prior to surface preparation and prepare concrete surfaces in accordance with SSPC-SP 13/SP CAB/NACE #6 (also called NACE 6).

2. Prior to surface preparation for degree of cleanliness and profile, prepare substrate cracks and areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges per CSM recommendations.
3. Evaluate the surface profile for prepared concrete surfaces to be coated by comparing the profile of the prepared concrete with the profile of the ICRI 310.2 (molded surface profile replicas). Prepare surface profile in accordance with the COATSPEC requirements and the CSM's recommendations.
4. Inspect prepared concrete substrates for surface cleanliness after cleaning, preparation, and/or drying, but prior to making repairs or applying a coat in the coating system. Reinspect repaired concrete surfaces for cleanliness prior to application of the coating system.
5. Prepare concrete substrates using methods such as dry abrasive blast cleaning, high, or ultra-high-pressure water jetting in accordance with SSPC-SP 13 /SP CAB /NACE #6 to meet the following requirements:
    a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances.
    b. Open up air voids or bugholes to expose their complete perimeter by blast cleaning or other methods. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable.
    c. Concrete substrate must be dry prior to the application of repair mortars, filler/surfaces, or coating system materials.
    d. Produce a concrete surface with a minimum pH of 9.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
    e. Following inspection of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt, and spent abrasive (if dry blast cleaning is used) leaving a dust free, sound concrete substrate.
    f. Remove debris produced by blast cleaning from the structures to be coated and dispose of legally off site.
6. Should abrasive blast cleaning or high or ultrahigh pressure water jetting not remove degraded concrete, use chipping or other appropriate tools to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Do not use equipment that will damage the underlying sound concrete such as pneumatic or electric chipping tools which will bruise or cause micro-cracking of the concrete substrate. Concrete substrates must be dry prior to the application of polymer based or mortars or filler/surfacers coating system materials.
7. Test moisture content of concrete to be coated in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method at least once for every 500 sq. ft. of surface area to be coated. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test.
8. If moisture is detected, the CSA in cooperation with the CTR shall perform additional moisture testing vis ASTM F1869 or ASTM F2170 to determine the extent of the moisture vapor transmission. The acceptable limit for the application of barrier coatings for ASTM F1869 is < 3lbs/1,000 sq ft/24 hours. The acceptable limit as per ASTM F2170 is an RH value <70 percent.

F. Masonry Surfaces:
   1. Prepare masonry surfaces such as Concrete Masonry Units (CMU) to remove chalk, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   2. Confirm masonry surfaces are dry prior to coating application. If pressure washing or low-pressure water blast cleaning or water jetting is used for preparation, allow the masonry to dry. Assess moisture content by the CTR to ensure moisture levels are in tolerance ranges suitable to the coating system being applied prior to coating application work proceeding. Provide Results and CTR to the Engineer or Construction Manager in writing from the CTR before proceeding with application.

G. Fiberglass Reinforced Plastic (FRP) Surfaces:
   1. Prepare FRP surfaces by first sanding to establish uniform surface roughness without any gloss remaining while minimizing any excessive removal of resin material. Second, vacuum clean to remove loose FRP dust, dirt, and other materials. Do not use compressed air. Then Solvent clean using clean white rags and allow solvent to evaporate completely before application of coating materials.

H. Existing Facilities:
   1. Existing equipment and metalwork shall be coated in accordance with the appropriate coating system specified for new work in paragraph 3.05.
   2. Modified work shall require the full coating system. Other work shall require cleaning and surface preparation as recommended by the CSM followed by 2 finish coats of the appropriate system.
   3. Contractor shall demonstrate that the existing coating is compatible with field coating by performing the adhesion test specified in paragraph 3.01 Adhesion Confirmation. Where unacceptable test results are obtained, the Contractor shall follow manufacturer's written instructions as to the necessity of a tie coat to provide a satisfactory bond between the existing coating, and the specified field coating or complete coating removal/recoating or further surface preparation work will be required until acceptable adhesion is achieved. The difference in cost between the specified coatings and that which is compatible with existing coatings, or work required to remove exiting coatings, will be paid for as extra work unless identified in the Scope of Work for the project already."
   4. If wall surfaces of structures are to be coated or recoated, the Owner shall be consulted and encouraged to determine actual surface conditions and clarify the requirements for surface repair. These requirements should then be specified by adding the following paragraph:
   5. "Abrasive blasting shall be used to clean wall surfaces of existing structures to be coated. Surfaces to be coated or recoated shall be repaired, cleaned, and finished to the standards as specified herein and in Section 03 30 00 for new concrete. Major repair work for wall surfaces of (specify surfaces) shall be as specified in Section 03 30 00."

3.03 APPLICATION

A. Workmanship:
   1. Apply coats to produce an even film of uniform thickness free from runs, drips, sags, ridges, waves, laps, and brush marks and completely coating corners and crevices.

2. Use equipment designed for application of the materials specified. Equip compressors with suitable traps and filters to remove water and oils from the air. Perform a paper blotter test when requested by the Construction Manager or Engineer to determine if the air is sufficiently free of oil and moisture so as not to produce deteriorating effects on the coating system. Limit the amount of oil and moisture in spray air to be less than the limits recommended by the CSM. Equip spray equipment with mechanical agitators, pressure gages, pressure regulators, and spray nozzles of the proper sizes.
3. Apply each coat evenly and sharply cut to line. Avoid over-spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, equipment, and all other adjacent areas and installations by taping, drop cloths, or other suitable masking measures.
4. Use coating applications method -- conventional or airless spray, plural component spray, brush or roller, or trowel -- as recommended by CSM.
5. Allow each coat to cure or dry thoroughly, according to CSM's printed instructions, prior to recoating.
6. Lightly sand glossy undercoats to provide a surface suitable for the proper application and adhesion of subsequent coats. Vary color for each successive coats for coating systems wherever possible to provide visual confirmation of coverage.
7. Prior to overall coating system application on complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces as per SSPC PA Guide 11 with the primer coat material using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties, Mixing and Thinning:
   1. Coatings, when applied, shall provide a satisfactory film and smooth even surface. Thoroughly stir, strain, and keep at a uniform consistency all coating materials during application. Mix coating materials consisting of 2 or more components in accordance with the CSM's instructions. Where necessary to suit the conditions of the surface, temperature, weather, and method of application, the coating may be thinned but only as recommended by the CSM. The VOC of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, do not reduce coating materials more than necessary to obtain the proper application characteristics. Use thinner as recommended by the CSM.

C. Atmospheric Conditions:
   1. Apply coatings only to surfaces that are dry and only under conditions of evaporation rather than condensation. Do not apply coating systems during rainy, misty weather, or to surfaces upon which there is frost or moisture condensation. During damp weather, when the temperature of the surface to be coated is within 10 degrees F of the dew point, forced dehumidification equipment may be used to maintain a temperature of minimum 40 degrees F and 10 degrees F above the dew point for the surfaces to be coated, the coated surface, and the atmosphere in contact with the surface. Maintain these conditions for a period of at least 8 hours or as recommended by the CSM. Where conditions causing condensation are severe, use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain the required atmospheric and surface temperature for proper coating application and cure at no additional cost to the Owner.

D. Concrete Substrate Temperatures and Detail Treatment:
   1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, and/or blistering in the coating system. The application of the filler/surface and the coating system will only be allowed during periods of falling temperature. This will require that application of the filler/surface and coating system only occur during the cooler evening hours. Include all cost for working outside of normal hours in the bid.
   2. Repair all bubbles, fish eyes, pinholes, or other discontinuities that form in the applied coating system material as recommended by the CSM. Repair pinholes that develop in the filler/surfacer material or in the first coat of the coating material in accordance with the CSM's recommendations prior to application of the next coat of material. Open up and fill completely all air voids behind or beneath the pinhole with the specified filler/surfacer/coating material. Abrade the coated area around the pinhole repair and recoat that area.
   3. Perform application detail work per CSM's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:
   1. Do not handle, work on, or otherwise disturb items that have been coated until the coating is completely dry and hard. Recoat or retouch shop-coated items after delivery at the site, and upon permanent erection or installation with specified coating when it is necessary to maintain the integrity of the film.

F. Method of Coating Application:
   1. Where 2 or more coats are required, provide sufficient compatible color additive, or contrasting color, in alternate coats to act as indicator of coverage, or the alternate coats shall be of contrasting colors. Do not use color additives containing lead or lead compounds which may be destroyed or affected by hydrogen sulfide or other corrosive gas, and/or chromium.
   2. Mechanical equipment, on which the equipment manufacturer's coating is acceptable, touch-up prime and coat with 2 coats of the specified coating system to match the color scheduled. Do not apply coatings to a surface until it has been prepared as specified. Apply the primer or first coat by brush to ferrous surfaces that are not blast cleaned. Coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces may be either brush or spray applied. After the prime coat is dry, visually inspect all surfaces, and mark all visible pinholes and/or holidays, repair in accordance with CSM's recommendations, and reinspect visually before applying succeeding coats. Unless otherwise specified, brush, roll, or trowel coats for concrete and masonry.

G. Film Thickness and Continuity:
   1. Confirm WFT following application of each coat.
   2. Do not exceed the surface area covered per gallon of coating for various types of surfaces recommended by the CSM. The first coat, referred to as the prime coat, on metal surfaces refers to the first full paint coat and not to solvent wash, grease emulsifiers, or other pretreatment applications. Apply coatings to the thickness specified and in accordance with these specifications.

3. Conduct visual observations of continuity of coating film quality at welds, projections (such as bolts and nuts), and crevices, to verify no holidays exist where the dry-mil thickness has been accepted. This continuity shall be the minimum required for these rough or irregular areas. Recoat pinholes and holidays to the required coverage.
4. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may need to be applied to achieve the specified DFT.
5. For concrete substrates, apply a complete skim coat of the specified filler/surfacer material over the entire substrate to produce a relatively flat continuous coatable surface prior to application of the coating system as required in the COATSPEC for the specific coating system. Apply the skim coat to the thickness recommended by the CSM and such that all open air voids and bugholes in the concrete substrate are completely filled prior to coating application.

H. Special Requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces that are inaccessible after assembly. Apply the final coat after erection. Coat structural friction connections and high tensile bolts and nuts after erection. Hand clean or power-tool clean areas damaged during erection and recoat with primer coat prior to the application of subsequent coats. Touch-up surfaces after installation. Confirm surfaces to be coated are clean and dry at the time of application.
2. Except for those to be filled with epoxy grout, coat the underside of equipment bases and supports that have not been galvanized with at least 2 coats of primer specified for system E-2 prior to setting the equipment in place. Provide coating system terminations at leading edges and transitions to other substrates in accordance with the CSM's recommendations or detail drawings.

I. Electrical and Instrumentation Equipment and Materials:
1. Electrical and instrumentation equipment and materials shall be shop coated by the equipment manufacturer in compliance with the standard (IEEE, ANSI, NEMA, etc.) referenced in the individual equipment specification. Before final acceptance, the Contractor shall touch up scratches on equipment with identical color coating. Finish shall be smooth, free of runs, and match existing finish. Prior to touching up scratches, Contractor shall fill them with an appropriate filler material approved by the CSM so evidence of prior scratches is not visible in the finish surface

3.04 CLEANUP

A. General:
1. Upon completion of coating, remove surplus materials, protective coverings, and accumulated rubbish, and thoroughly clean surfaces and repair overspray or other coating-related damage.

3.05 COATING SYSTEM SPECIFICATION SHEETS (COATSPEC)

A. General:

1. Coating systems for different types of surfaces and general service conditions for which these systems are normally applied are specified on the following COATSPEC sheets. Coat surfaces in accordance with the COATSPEC to the system thickness specified. Use coating systems as specified in paragraph 3.06. In case of conflict between the schedule and the COATSPECS, the requirements of the schedule take precedence.
2. Coating Specification Sheets included in Table A are included this paragraph 3.05.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
E-1	Epoxy	Metal	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
E-1-G	Epoxy	Galvanized Steel	Interior; exterior, covered non-corrosive exposure. Do not use in immersion service.
E-2	Epoxy	Metal	Exposed to high humidity, condensing conditions moderately corrosive vapors.
E-2-C	Epoxy	Concrete or masonry	Exposed to high humidity, condensing conditions moderately corrosive vapors.
E-3	Epoxy	Concrete or masonry	Non-immersed, moderately corrosive vapor environment, color required.
E-4	Epoxy	Concrete, masonry, plaster, gypsum board	Interior of buildings.
E-5	Epoxy	Metal or concrete	Below grade (buried).
WBPU-1	Clear finish	Wood	Interior
ELA-1	Elastomeric Acrylic	Concrete or dense masonry block where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior protection and aesthetics.	Exterior direct sunlight. Concrete or dense masonry block where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior protection and aesthetics.
EU-1	Zinc-epoxy-polyurethane system	Ferrous Metal	Exterior, exposed to direct sunlight, moderately corrosive non-immersed – vapor exposure.
EFL-1	Chemical Resistant Novolac Epoxy Flooring with Anti-Slip Broadcast	Concrete	Interior areas subjected to chemical splash and spill. (NOT SECONDARY CONTAINMENT). For Secondary Containment see Section 09 96 00
EFL-2	Epoxy Flooring with Anti-Slip Broadcast	Concrete	Interior areas such as electrical Rooms, mechanical rooms, storage rooms, washrooms and other common Areas of foot or light cart traffic. Not subjected to chemical or UV exposure.
EFL-3	Epoxy Flooring with Anti-Slip and UV protective Topcoat	Concrete	Flooring with Exterior Exposure or other forms of UV exposure such as interior areas with lots of windows.
EU-1-FRP	Specialty Primer plus Polyurethane Finish Coat	Exterior of FRP pipe and tanks, etc.	Exterior, exposed to direct sunlight, non-immersed.
G	Grease	Metal	Ferrous Metal: Ferrous metal surfaces shall be prepared in accordance with SSPC-SP 1 (Solvent Cleaning.)

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
HH-1	Next Generation Epoxy Phenolic	Metal	Temperature to 400 degrees F.
HH-2	TMIC – Titanium Modified Inorganic Co-polymer	Metal	Temperature to 1200 degrees F.
L-1	100% Acrylic Latex	Concrete, masonry, plaster, gypsum board	Interior including existing coated concrete.
L-2	100% Acrylic Latex	PVC and CPVC pipe	Exterior, direct sunlight exposure.
L-3	100% Acrylic- to Metal	Ferrous Metal	Interior or Exterior
L-4	Acrylic Latex	Wood	Interior
M-1	Petrolatum based mastic or wax based wrapping tapes	Metal	Below grade (buried) or where little to no surface preparation can be performed on piping or structural steel.
M-2	Epoxy mastic or equal	Ferrous Metal	Interior moderately, corrosive environment, confined enclosures, where minimal surface preparation is possible. Non-immersed.
S-1	Penetrating acrylic stain, color required	Concrete	Non-immersed, exposure to moisture and sunlight.
S-2	Silane or Siloxane or Blended Siloxane & Silane Sealer	Concrete Floors	Non-immersed, non-corrosive. Interior or exterior for waterproofing.
S-3	Silane or Siloxane or Blended Siloxane & Silane Sealer	Concrete or Masonry Walls	Exterior or Interior – Weathering Exposure, Non-Corrosive.
AG1	Single Component Silicone Clear	Anti-Graffiti	Exterior Concrete or Steel or previously coated surfaces.

Coating System Specification Sheets (COATSPEC)

Coating System Identification: E-1

1. Coating Material:	Epoxy
2. Surface:	Metal
3. Service Condition:	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
4. Surface Preparation:	
a. General:	Shop primed surfaces which are to be incorporated in the work where recoat times have been exceeded shall be prepared in the field by cleaning surfaces by sanding to produce uniform profile of .5 to 1.0 mils and solvent cleaned per SSPC-SP 1. Damaged shop coated areas shall be cleaned in accordance with SSPC-SP6/NACE #3 Commercial Abrasive Blast Cleaning or SSPC-SP 11 to achieve a uniform surface profile of 2.0 to 2.5 mils in the metal substrate and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive sanding and vacuum cleaning prior to receiving finish coats.
b. Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6/NACE#3 (Commercial Blast Cleaning) to achieve a uniform, surface profile of 2.0 to 2.5 mils.

Coating System Specification Sheets (COATSPEC)	
c. Nonferrous and Galvanized Metal:	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 1. Areas of rust penetration shall be spot blasted to SSPC-SP6/NACE#3 Commercial blast (to achieve the 2.0- to 2.5-mil surface profile) and spot primed with the specified primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
5. Application	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coats shall be an epoxy primer compatible with the specified finish coats and applied in accordance with the written instructions of the CSM.
c. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC-SP 1 (Solvent Cleaning).
6. System Thickness:	10 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to achieve the specified system thickness.
Coating System Identification: E-1-G	
1. Coating Material:	Epoxy
2. Surface:	Galvanized Steel
3. Service Condition:	Interior; exterior, covered, non-corrosive exposure.
4. Surface Preparation:	
a. General:	Damaged galvanized steel areas with exposed ferrous metal and/or rusted shall be cleaned in accordance with SSPC-SP 16 to achieve a uniform 1.0- to 1.5-mil profile and spot primed with the primer specified.
b. Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 to impart a 1- to 2-mil profile to the galvanized steel surfaces. Where this cannot be performed due to access limits, prepare by abrading in accordance with SSPC-SP 3, Power Tool Cleaning to impart a 1.0- to 1.5-mil profile uniformly to the galvanized steel surfaces.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Galvanized Metal:	Nonferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC-SP 1 (Solvent Cleaning).
6. System Thickness:	5 to 8 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-2	
1. Coating Material:	Epoxy
2. Surface:	Metal
3. Service Condition:	Non-immersed, moderately corrosive environment, color required.
4. Surface Preparation:	

Coating System Specification Sheets (COATSPEC)	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC-SP 5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
	Damaged shop coating shall be cleaned in accordance with SSPC-SP6/NACE #3 Commercial Blast Cleaning or SSPC-SP 11 and vacuum cleaning and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting or abrading prior to receiving finish coats if the maximum recoat time for the primer has been exceeded. This cleaning must produce a uniform 1.0- to 1.5-mil profile in the intact shop primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
b. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 to achieve a uniform surface profile of 1.0 to 1.5 mils. Galvanized steel with this E-2 coating system shall not be used in routinely wet exposures.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coat shall be an epoxy primer compatible with the specified finish coats.
c. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal, non-immersed, shall be coated prior to the application of the prime coat with a grease emulsifying agent in accordance with the CSM's written instructions. Nonferrous metal to be immersed shall not be painted. Galvanized metal shall not be immersed even if it is painted. If non-ferrous metals are not to be immersed, prepare in accordance with SSPC-SP 16.
6. System Thickness:	16 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-2-C	
1. Coating Material:	Epoxy
2. Surface:	Concrete or masonry
3. Service Condition:	Non-immersed, lightly corrosive vapor environment, color required.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days following initial concrete placement and allowed to dry to the moisture content recommended by the CSM before coating work proceeds. Moisture content shall be tested per ASTM D4263, Moisture Test by Plastic Sheet Method. Any moisture on back of plastic sheet means coating application cannot proceed until the concrete or masonry has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Cleaning can be performed using abrasive blast cleaning as per SSPC-SP 13/NACE #6 and SSPC SP CAB 1 or water blast cleaning methods to produce a minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. After cleaning, all air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.

Coating System Specification Sheets (COATSPEC)	
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping.
	Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances.
	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Application:	Field
a. General:	Apply filler/surfacer as recommended by CSM to fill bugholes and air voids or block texture, etc. leaving a uniformly filled surface that does not produce blowholes or outgassing causing pinholes in the coating system.
	All concrete or masonry surfaces shall be in an SSD condition during all cementitious repair processes meeting most stringent requirements identified by repair product manufacturer.
	Filler/Surfacers shall dry a minimum of 48 hours prior to application of prime coat or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	16 to 20 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-3	
1. Coating Material:	Epoxy
2. Surface:	Concrete or masonry
3. Service Condition:	Non-immersed, moderately corrosive vapor environment, color required.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM before coating work proceeds. Moisture testing shall be performed in accordance with ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating application cannot proceed until the concrete or masonry has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Surface preparation can be performed by abrasive blast cleaning as per SSPC-SP 13/NACE #6 and SSPC SP CAB 1 or high pressure water jet cleaning and must achieve a uniform concrete surface profile of CSP 3 in accordance with ICRI 310.2. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.

Coating System Specification Sheets (COATSPEC)	
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping.
	Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign, loose, and deleterious substances.
	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Application:	Field
a. General:	Apply filler/surfacer as recommended by CSM to fill bugholes and air voids or block texture, etc. leaving a uniformly filled surface that does not produce blowholes or outgassing causing pinholing of the coating system. Filler/surfacers shall dry a minimum of 48 hours prior to application of prime coat or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	15 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-4	
1. Coating Material:	Epoxy
2. Surfaces:	Concrete, masonry, plaster, gypsum board
3. Service Condition:	Interior
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content of gypsum and plaster surfaces may be tested with a Delmhorst Instrument Company moisture detector, or equal. Moisture levels of concrete and masonry shall be tested as per section 3.02. Moisture coated as recommended by the CSM must be met prior to coating application. Loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00. Surface preparation shall produce a concrete surface profile of CSP 2 in accordance with ICRI 310.2. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.
b. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, exterior masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.

Coating System Specification Sheets (COATSPEC)	
c. Plaster:	Plaster surfaces shall be dry, clean, and free from grit, loose plaster, and surface irregularities. Cracks and holes shall be repaired with acceptable patching materials, keyed to existing surfaces, and sandpapered smooth. Surfaces shall be cleaned with clean water by washing and scrubbing to remove foreign and deleterious substances.
5. Application:	Field
a. General:	Block Filler shall be multiple component epoxy block filler or an acrylic based or waterborne epoxy based block filler and shall dry a minimum of 48 hours prior to primer application or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	10 mils dry film, excluding block filler and sealer.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness
Coating System Identification: E-5	
1. Coating Material:	Polyamidoamine epoxy
2. Surface:	Metal or concrete
3. Service Condition:	Below grade (buried, exterior) in contact with soil.
4. Surface Preparation:	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC-SP 10 (Near White Metal Blast Cleaning).
b. Nonferrous Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 to achieve a uniform surface profile of 2.0 to 2.5 mils.
c. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested in accordance with ASTM D4263, Moisture by Plastic Sheet Method. Any moisture on back of plastic sheet means coating cannot proceed until the concrete or masonry has dried out. Except as otherwise specified, loose concrete and laitance shall be removed from surfaces by abrasive blasting as per SSPC CAB #1 and SSPC SP 13/NACE #6 and chipping. Voids and cracks shall be repaired as specified in Section 03 30 00. Concrete surface preparation can be performed using abrasive blast cleaning or water blast cleaning methods and must achieve a concrete surface profile of CSP 3 in accordance with ICRI 310.2.
5. Application:	Field
6. System Thickness:	16 mils
7. Coating:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: WBPU-1	
1. Coating Material:	Clear Polyurethane
2. Surface:	Wood
3. Service Condition:	Interior

Coating System Specification Sheets (COATSPEC)	
4. Surface Preparation:	Wood surfaces shall be cleaned of dirt, oil or other foreign substances with mineral spirits, scrapers, sandpaper, or wire brush. Finished surfaces exposed to view shall be smoothed by planing or sandpapering. Millwork shall be sandpapered and given a coat on sides and raw edges before installation. Built-in surfaces of windowsills shall be double coated. Glazing rabbets and beads in exterior sash and doors shall be double coated. Small, dry, seasoned knots shall be surface scraped, sandpapered, and thoroughly cleaned and shall be given a thin coat of a clear knot sealer before application of the first coat. Large, open, unseasoned knots, and beads or streaks of pitch shall be scraped off; however, if the pitch is still soft, it shall be removed with mineral spirits or turpentine, and the resinous area shall be coated with knot sealer prior to coating. After the first coat, holes and imperfections shall be filled with putty or plastic wood, allowed to dry and sandpapered smooth.
5. Application:	Field
a. General:	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
6. System Thickness:	2-3 Coats as per CSM Instructions.
7. Coatings:	
a. Primer:	One coat at CSM's recommended application instructions.
b. Finish:	One or more coats at CSM's recommended application instructions.
Coating System Identification: ELA-1	
1. Coating Material:	Elastomeric Acrylic
2. Surface:	Concrete or Dense Masonry where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior weathering protection, breathability and aesthetics.
3. Service Condition:	Interior or exterior, above grade, non-submerged direct sunlight – moderately corrosive due to vapor corrosion environment.
4. Surface Preparation:	
	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
	If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials.

Coating System Specification Sheets (COATSPEC)	
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete or masonry has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by Low Pressure Water Cleaning (LPWC with Pressures < 5000 psi) or by abrasive blasting and chipping as per SSPC-SP 13/NACE #6/SSPC-CAB #1-3. Voids and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation may open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 1-2 in accordance with ICRI 310.2.
5. Application:	Field
a. General:	Surfacer or fillers can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill bugholes and voids. These materials must be compatible with the primers and finish coats or preferably, a more textured version of this coating system can be selected to fill air voids (bugholes), etc. All cementitious products shall be applied to surfaces in an SSD condition.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
6. System Thickness:	16 to 24 mils DFT
7. Coatings:	
a. Primer:	One coat at 3-5 mils DFT
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness
c. Testing:	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired.
d. Pinhole and Holiday Repair Procedure:	Pinholes or holidays identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EU-1	
1. Coating Material:	Zinc-Epoxy-Polyurethane System
2. Surface:	Ferrous Metal
3. Service Condition:	Exterior, exposed to direct sunlight, moderately corrosive, non-immersed.
4. Surface Preparation:	
a. General:	Undamaged shop primed surfaces which have exceeded recoat times which are to be incorporated in the work shall be prepared in the field by sanding to produce a uniform surface profile followed by Solvent Cleaning per SSPC-SP 1. Damaged shop coated areas shall be cleaned in accordance with SSPC-SP 11 and recoated with the primer specified.
b. Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6 (Commercial Blast Cleaning) 2.0–2.5 mils. Ductile iron surfaces to be coated shall be abrasive blast cleaned in accordance with paragraph 3.02 Metallic Surfaces.
	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 11 (Power Tool Cleaning to Bare Metal). Areas of rust penetration shall be spot blasted to SSPC-SP 6/NACE #3 10 (Commercial Near White Blast Cleaning) and spot primed with the specified primer.

Coating System Specification Sheets (COATSPEC)	
c. Galvanized Metal:	Damaged galvanized steel areas with exposed ferrous metal and/or rusted shall be cleaned in accordance with SSPC-SP 165 (White Metal Brush Off Abrasive Blast Cleaning for Galvanized and Non-Ferrous metal) or Power Tool Cleaned to Bare Metal in accordance with SSPC-SP 11 to achieve a uniform 1.0- to 1.5-mil profile. The zinc primer is NOT used on galvanized steel but is spot primed with the primer specified for galvanized metal as recommended by the CSM.
	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 (Brush Off Abrasive Blast Cleaning for Galvanized and Non-Ferrous metal) to impart a 1.0- to 2.0-mil profile to the galvanized or non-ferrous steel surfaces. Where this cannot be performed, prepare by abrading in accordance with SSPC-SP 113, Power Tool Cleaning to bare metal to impart a 1.0- to 1.5-mil profile uniformly to the galvanized steel surfaces.
	For EU-1 over galvanized steel, **DELETE the zinc rich primer**.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coats shall be a zinc rich epoxy or polyurethane primer compatible for use with urethane finish coats and applied in accordance with written instructions of the CSM or in the case of CARB or SCAQMD applications, prime with specified primer that is not zinc rich. In these cases, only a 2-coat system is applied.
6. System Thickness:	3-4 mils of zinc rich primer, one intermediate or primer epoxy coat at 5-6 mils and one finish coat of polyurethane at 2-3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT
b. Intermediate:	One coat at CSM's recommended DFT
c. Finish:	One coat at CSM's recommended DFT per coat to meet the specified system thickness
Coating System Identification: EFL-1	
1. Coating Material:	100% Solids Chemical Resistant Novolac Epoxy with Anti-Slip Aggregate Broadcast
2. Surface	Concrete
3. Service Condition	Interior areas subject to chemical splash and spill (NOT SECONDARY CONTAINMENT)
4. Surface Preparation:	
a. General	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.

Coating System Specification Sheets (COATSPEC)	
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-40 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	6-15 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired. Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.
9. Pinhole and Holiday Repair Procedure:	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EFL-2	
1. Coating Material	100% Solids Epoxy Floor Coating
2. Surface	Concrete
3. Service Conditions	Interior Floors in Common Areas not subjected to chemical exposure or UV.
4. Surface Preparation	

Coating System Specification Sheets (COATSPEC)	
a. General	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-40 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	One Coat at 6-15 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired. Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.
9. Pinhole and Holiday Repair Procedure.	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EFL-3	

Coating System Specification Sheets (COATSPEC)	
1. Coating Material	100% Solids Epoxy Floor Coating /UV Resistant Polyurethane/Polyaspartic
2. Surface	Concrete
3. Service Condition	Exterior concrete floor surfaces subjected to UV but not subjected to chemical exposure, or interior concrete floor surfaces with UV exposure
4. Surface Preparation	
a. General	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-52 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	One Coat at 2 - 9.6 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired.

	Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.
9. Pinhole and Holiday Repair Procedure	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EU-1-FRP	
1. Coating Material:	Epoxy Primer plus Polyurethane Finish Coat.
2. Surface:	Exterior of FRP Pipe and Tanks, etc.
3. Service Condition:	Exterior, exposed to direct sunlight, non-immersed.
4. Surface Preparation:	
a. General:	Clean to remove loose dirt, dust, or other contaminants.
	Prepare surfaces by sanding to produce roughness to achieve a uniform, minimum surface profile of 1.5 to 2.0 mils. Abrasive Sweep blasting can also be used providing care is taken not to over blast.
	Solvent clean thoroughly using solvent as recommended by the CSM.
	Thoroughly clean to remove loose debris by vacuum cleaning.
5. Application:	Field
a. General:	Apply primer coat and thin as recommended by the CSM provided the coating applied complies with prevailing air pollution control regulations.
	Apply finish coat as recommended by the CSM.
6. System Thickness:	Primer to 2-4 mils and finish coat is 2-3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One coat at CSM's recommended DFT per coat to meet the specified system thickness.
Coating System Identification: G	
1. Coating Material:	Grease
2. Surface:	Metal
3. Surface Preparation:	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC-SP 1 (Solvent Cleaning).
4. Application:	Field
	Coating shall be applied with stiff brush, hand swab, or airless spray gun.
5. System Thickness:	50 square feet per gallon.
6. Coating:	One coat of grease coating.
Coating System Identification: HH-1	
1. Coating Material:	Formulations vary by manufacturer.
2. Surface:	Metal
3. Service Condition:	Temperature to 400 degrees F.
4. Surface Preparation:	Metal surfaces shall be prepared in accordance with SSPC-SP 10 (Near White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
5. Application:	Field
	Curing as required by CSM.
6. System Thickness:	6.5 to 10 mils dry film varies by manufacturer.

Coating System Specification Sheets (COATSPEC)	
7. Coating:	DFT varies by manufacturer.
Coating System Identification: HH-2	
1. Coating Material:	Formulations vary by manufacturer.
	TMIC – Titanium Modified Inorganic Co-polymer.
2. Surface:	Metal
3. Service Condition:	Temperature to 1200 degrees F
4. Surface Preparation:	Metal surfaces shall be prepared in accordance with SSPC-SP 10 (Near White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
5. Application:	Field
	Curing as required by CSM.
6. System Thickness:	6.5 to 10 mils dry film varies by manufacturer.
7. Coating:	DFT varies by manufacturer.
Coating System Identification: L-1	
1. Coating Material:	100 percent Acrylic Latex.
2. Surfaces:	Concrete, masonry, plaster, gypsum board.
3. Service Condition:	Interior including existing coated concrete.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content of gypsum and plaster surfaces shall be tested with a Delmhorst Instrument Company moisture detector, or equal. Moisture levels of concrete and masonry shall be tested as per ASTM D4263, Plastic Sheet Method and section 3.02. Moisture content must meet CSM's recommendation for coating work to proceed. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
b. Existing Coated Concrete:	Remove all loose coating down to a sound substrate or intact, well-adhered existing coating by scraping or other means. Then, abrade all surfaces to achieve a 0.5 to 1.5-mil uniform profile and vacuum clean to remove all loose dirt, paint chips, and dirt.
c. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be filled with block filler compatible with the specified primer.
d. Plaster:	Plaster surfaces shall be dry, clean, and free from grit, loose plaster, and surface irregularities. Cracks and holes shall be repaired with acceptable patching materials, keyed to existing surfaces, and sandpapered smooth. Surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. After cleaning, surfaces shall be sealed with a compatible sealer.
e. Gypsum Wallboard:	Tape joints and spackled nail heads shall be sanded smooth and dusted. Seal with PVA sealer for interior uses only.
5. Application:	Field
a. General:	Sealer or filler shall dry a minimum of 48 hours prior to primer application.
	Drying time between coats shall be as recommended by CSM.

Coating System Specification Sheets (COATSPEC)	
6. System Thickness:	4 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: L-2	
1. Coating Material:	100 percent Acrylic Latex.
2. Surface:	PVC and CPVC pipe.
3. Service Condition:	Interior and Exterior non-corrosive to mildly corrosive atmospheres suitable for direct sunlight exposure.
4. Surface Preparation:	Plastic pipe shall be cleaned with solvent compatible with the specified primer and sanded to roughen surfaces to achieve a uniform surface profile of 1.0 to 1.5 mils. Vacuum clean or wipe with a damp rag after sanding to remove all loose dust, plastic particles, and dirt.
5. Application:	Field
6. System Thickness:	3 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: L-3	
1. Coating Material:	100 percent Acrylic – Direct to Metal or with a Primer.
2. Surface:	Ferrous Metal, Galvanized Metal and Non-Ferrous Metals.
3. Service Condition:	Interior or Exterior
4. Surface Preparation:	
a. Ferrous Metals:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6/NACE #3 (Commercial Blast Cleaning) unless specified otherwise. Impart a 1.5- to 2.0-mil profile to substrate.
	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 1 (Solvent Cleaning). Areas of rust penetration shall be spot blasted to SSPC-SP 10/NACE #2 (Near White Blast) and spot primed with the specified primer.
	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning).
b. Nonferrous and Galvanized Metal:	Galvanized or nonferrous surfaces shall be prepared in accordance with SSPC-SP 1 (Solvent Cleaning) for doors and frames and other general usage or SSPC-SP 16 in areas where a more robust surface preparation is required. Solvent clean as per SSPC-SP 1 or vacuum clean after Brush Blast Cleaning in accordance with SSPC-SP 16.
5. Application:	Field
6. System Thickness:	4 to 6 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: L-4	

Coating System Specification Sheets (COATSPEC)	
1. Coating Material:	Acrylic Latex
2. Surface:	Wood
3. Service Condition:	Interior
4. Surface Preparation:	Wood surfaces shall be cleaned of dirt, oil or other foreign substances with mineral spirits, scrapers, sandpaper, or wire brush. Finished surfaces exposed to view shall be smoothed by planing or sandpapering. Millwork shall be sandpapered and given a coat of the specified primer on all sides before installation. Built-in surfaces of windowsills shall be double primed. Glazing rabbets and beads in exterior sash and doors shall be double primed. Small, dry, seasoned knots shall be surface scraped, sandpapered, and thoroughly cleaned and shall be given a thin coat of an acceptable knot sealer before application of the priming coat. Large, open, unseasoned knots, and beads or streaks of pitch shall be scraped off; however, if the pitch is still soft, it shall be removed with mineral spirits or turpentine, and the resinous area shall be coated with knot sealer prior to priming. After priming, holes and imperfections shall be filled with putty or plastic wood, colored to match the finish coat, allowed to dry, and sandpapered smooth.
5. Application:	Field
6. System Thickness:	4.0- 6.0 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: M-1	
1. Coating Material:	Petrolatum based mastic or wax based wrapping tapes.
2. Surfaces:	Metal
3. Service Condition:	Below grade (buried) or where little to no surface preparation can be performed on piping or structural steel.
4. Surface Preparation:	Remove loose scale, rust, dirt, excessive moisture, or frost from the surface in accordance with SSPC-SP 2 (Hand Tool Cleaning).
5. Application:	All surfaces shall be hand rubbed or brushed with a priming paste recommended by the CSM. Sharp projections such as threads, irregular contours, or badly pitted areas shall receive a liberal amount of priming paste to ensure maximum protection of metal throughout.
	On irregular shaped surfaces, (i.e., nuts, bolts, flanges, valves, etc.) the Contractor shall use either of the following systems recommended by the CSM.
	A. Apply recommended mastic by hand in sufficient quantity to build an even contour over entire surface. The Contractor shall pay particular attention to ensure that folds and air pockets within the mastic layer are thoroughly pressed out prior to subsequent application of tape.
	OR:
	B. An extra layer of tape shall be cut and carefully molded around sharp projections, nuts, bolts, etc., before final application of tape, in order to meet specified system thickness.
	Tape shall be spirally wrapped with a 55-percent overlap and sufficient tension and pressure to provide continuous adhesion without stretching the tape. Edges of tape must be continuously smoothed and sealed by hand during wrapping. On vertical application, contractor shall begin at bottom and proceed upward creating a weatherboard overlap.
6. System Thickness:	Smooth contours shall have a minimum thickness of 50 mils while nuts, bolts, and sharp projections shall be 100 mils.

Coating System Specification Sheets (COATSPEC)	
7. Tape:	Number and types of tape wraps shall be in accordance with the CSM's written instructions.
Coating System Identification: M-2	
1. Coating Material:	Epoxy mastic or equal
2. Surface:	Ferrous Metal
3. Service Condition:	Interior, corrosive environment, confined enclosures, where minimal surface preparation is possible.
4. Surface Preparation:	
a. Ferrous Metal:	All uncoated ferrous metal surfaces shall be prepared in accordance with SSPC-SP 3 (Power Tool Cleaning), or SSPC-SP 11 (Power to Cleaning to Bare Metal) and SSPC Hand Tool Cleanings prior to assembly. Surface preparation to achieve a uniform surface profile of 2.0 to 2.5 mils. Shop primed ferrous metal surfaces and fabricated assemblies shall be clean and dry prior to the application of field coats. Following assembly, the Contractor shall smooth welds and prominences using power tools prior to the application of the field applied coatings.
5. Application:	Field
a. General:	Prior to the application of field applied coatings, welds, back-to-back angles, sharp or rough edges and weld splatter shall be brushed with the specified prime coat and allowed to cure overnight.
6. System Thickness:	10-15 mils dry film.
7. Coatings:	
a. Prime:	One coat of the CSM's recommended DFT.
b. Finish:	One or more coats of CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: S-1	
1. Coating Material:	Penetrating acrylic stain, color required.
2. Surface:	Concrete
3. Service Condition:	Non-immersed, exposure to moisture and sunlight.
4. Surface Preparation:	Low pressure water cleaning (LPWC at pressures <5000 psi or industry standard acid etch or other preparation as approved by the CSM).
5. Application:	
a. General:	Drying time between coats shall be as specified by the CSM for the site conditions.
b. Coatings:	Minimum of two coats overall (coat as many times as required to achieve desired color).
6. System Thickness:	200 square feet per gallon maximum or as recommended by the CSM
7. Color Selection:	As approved by the Owner.
Coating System Identification: S-2	
1. Coating Material:	Penetrating Water Repellent (Clear and Non-Film Building).
2. Surface:	Concrete Floors
3. Service Condition:	Exterior and Interior
4. Surface Preparation:	Clean surfaces of all traces of dirt, dust, efflorescence, mold, salt, grease, oil, asphalt, laitance, curing compounds, paint, coatings, and other foreign materials by low pressure water cleaning (LPWC at pressures <5000 psi) and/or chemical cleaners or other preparation as approved by the CSM.

Coating System Specification Sheets (COATSPEC)	
a. Concrete	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested with a Delmhorst Instrument Company moisture detector or equal. Acceptable content for coating application to be recommended by CSM. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
5. Application:	
a. General:	As per CSM's instructions. Drying time before placing into service shall be as recommended by the CSM for site conditions.
6. System Coverage:	Follow CSM's recommendations.
7. Color Selection:	Clear
Coating System Identification: S-3	
1. Coating Material:	Penetrating Water Repellent (Clear & Non-Film Building).
2. Surface:	Concrete and Masonry Walls
3. Service Condition:	Exterior and Interior
4. Surface Preparation:	Clean surfaces of all traces of dirt, dust, efflorescence, mold, salt, grease, oil, asphalt, laitance, curing compounds, paint, coatings, and other foreign materials by brush-off blast, low pressure water cleaning (LPWC at pressures <5000 psi) and/or chemical cleaners or other preparation as approved by the CSM.
a. Concrete	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested with a Delmhorst Instrument Company moisture detector or equal. Acceptable moisture content to be as recommended by the CSM. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
b. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used.
5. Application:	
a. General:	Drying time before placing into service shall be as recommended by the CSM for site conditions.
6. System Coverage:	Follow CSM's recommendations.
7. Color Selection:	Clear
Coating System Identification: AG1	
1. Coating Material:	Single Component Silicone (Clear)
2. Surface:	Concrete and Steel
3. Service Condition:	Exterior
4. Surface Preparation:	Clean surfaces of all traces of dirt, dust, efflorescence, mold, salt, grease, oil, asphalt, laitance, curing compounds, and other foreign materials by, Low Pressure Water Cleaning (LPWC at pressures <5000 psi) and/or chemical cleaners or other preparation as approved by the CSM.
a. Concrete	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested with a Delmhorst Instrument Company moisture detector or equal. Acceptable moisture content to be as recommended by the CSM. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.

Coating System Specification Sheets (COATSPEC)	
b. Metals & Coated Surfaces	Previously coated metals and bare non-ferrous metals shall be cleaned by Low Pressure Water Cleaning (LPWC using pressures <5000 psi) to remove all oil, grease, dust, dirt and other foreign contaminants. All surfaces must be dry.
5. Application:	
a. General:	Drying time before placing into service shall be as recommended by the CSM for site conditions.
b. Coatings:	Apply as per CSM instructions.
6. System Thickness:	Follow CSM's recommendations.
7. Color Selection:	Clear

3.06 COATING SYSTEMS SCHEDULE (FINISH SCHEDULE)

A. General:

1. Specific coating systems, colors, and finishes for rooms, galleries, piping, equipment, and other items that are coated are specified in the following coating system schedule. Unless otherwise specified in the coating system schedule, the word "interior" shall mean the inside of a building or structure, and the word "exterior" shall mean outside exposure to weather elements.

Coating Systems Schedule (Finish Schedule)		
Location/Surface	**Coating System Identification**	**Standard Color**
General: All Surfaces not Specified by Area or Structure		
1. Structural Steel and Metal Decking	E-2 or EU-1	Note 2
2. Galvanized metal	Uncoated unless noted otherwise	
3. Stainless steel	Uncoated unless noted otherwise	
4. Equipment and Metal Appurtenances		
a. Equipment, non-immersed, unless otherwise specified		
1) Interior	E-1	Note 2
2) Exterior	EU-1	Note 2
b. High temperature equipment operable at		
1) 200 to 400 degrees F	HH-1	Note 2
2) above 400 degrees F to 1200 degrees F	HH-2	Aluminum or Black
c. Existing equipment		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		Note 3
a) Interior	E-1	Note 3, Match existing color
b) Exterior	EU-1 without primer	Note 3, Match existing color
d. Diffusers and grilles on coated surfaces, unless otherwise specified		
1) Interior	E-1	Match background color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
2) Exterior	EU-1	Match background color
e. Diffusers and grilles on uncoated surfaces, unless otherwise specified		
1) Interior	E-1	Match background color
2) Exterior	EU-1	Match background color
f. Existing diffusers and grilles		
1) Not damaged not modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1 without primer	Match existing color
g. Electrical switchgear panels, unit substations, motor control centers, power transformers, distribution centers, and relay panels; interior and exterior	See paragraph 3.03 Electrical and Instrumentation Equipment and Materials	ANSI 61 Grey (outside) FS 27880 White (inside)
h. Instrumentation panels, graphic indicating panels, indicating and transmitting field panels, unless otherwise specified		
1) Interior		FS 26306 Grey (outside) FS 27880 White (inside)
2) Exterior		FS 27722 White (outside) FS 27880 White (inside)
i. Existing electrical and instrumentation panels		
1) Not damaged by work in this contract	Uncoated	--
2) Damaged or exposed to outside surfaces by work in this contract		
a) Interior	E-1	FS 26306 Grey
b) Exterior	EU-1 without primer	FS 26306 Grey (Electrical) FS 27722 White (Instrumentation)
5. Conduit, Piping and Ductwork		
a. Ferrous, non-ferrous and galvanized piping, and appurtenant hangers and supports, non-immersed, unless otherwise specified.		
1) Interior – noncorrosive	E-1	FS 26306 Grey
2) Exterior – noncorrosive	EU-1	FS 26306 Grey
3) Buried piping	M-1 or M-2	Not required
b. Ferrous piping, appurtenant and supports, non-immersed	E-2	To be determined

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
c. Conduit, outlet and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports on coated surfaces, unless otherwise specified.		
1) Interior	E-1	Match background color
2) Exterior	EU-1	Match background color
d. Conduit, outlets and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps and supports on uncoated surfaces, unless otherwise specified		
1) Interior	E-1	FS 26306 Grey
2) Exterior	EU-1	FS 26306 Grey
e. Existing conduit, outlet and junction boxes, lighting transformers, lighting communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1	Match existing color
f. Racked conduits and cable trays	Uncoated	--
g. Insulated pipe jacketing	Uncoated	--
h. Plastic, fiberglass and flexible conduit and piping		
1) Unless otherwise specified	Uncoated	--
2) PVC and CPVC Piping	L-2	FS 26306 Grey
a) Exposed to direct sunlight	L-2	FS 26306 Grey
b) Not exposed to direct sunlight	L-2	FS 26306 Grey
i. High temperature piping operable at		
1) 200 to 750 degrees F	HH-1	FS 26306 Grey
2) Above 750 degrees F to 1,200 degrees F	HH-2	Aluminum or Black
j. Exposed ductwork, unless otherwise specified	Uncoated	--
6. Concrete, Grout, Masonry and Plaster		
a. Immersed tank and channel walls and bottoms unless otherwise specified in 09 96 00.	In accordance with Section 07 16 00	--
b. Outside concrete walls below grade common with dry area or room	In accordance with Section 07 11 13 and 07 13 26	--
c. Walls and ceilings		
1) Precast concrete or colored masonry	Uncoated	--
2) Exterior, unless otherwise specified	Uncoated	--
3) Interior, unless otherwise specified	E-4	Note 2
d. Concrete equipment bases unless otherwise specified	E-4	Match equipment color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
e. Floors unless otherwise specified	S-2	Note 2
f. Existing coated surfaces.	L-1	Match existing color
7. Door and Door Frames		
a. Doors unless otherwise specified		
1) Ferrous metal		
a) Interior	E-1	Note 2
b) Exterior	EU-1	Note 2
2) Aluminum	Uncoated	--
3) Other	Plastic laminate	Formica 947 Brown
4) Existing		
a) Not damaged by work in this contract	Uncoated	--
b) Damaged, exposed, or modified by work in this contract		
(1) Interior	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
(2) Exterior	EU-1	Match existing color
b. Door frames unless otherwise specified		
1) Adjacent wall coated		
a) Interior	E-1	Match wall color
b) Exterior	EU-1	Match wall color
2) Adjacent wall uncoated		
a) Interior	E-1	Note 2
b) Exterior	EU-1	Note 2
3) Aluminum	Uncoated	--
4) Existing		
a) Not damaged by work in this contract	Uncoated	--
b) Damaged, exposed, or modified by work in this contract		
(1) Interior	E-1	Match existing color
(2) Exterior	EU-1 without primer	Match existing color
8. Handrails, Gratings, Floor Plates, Manhole Covers, and Hatches		
a. Unless otherwise specified	Uncoated	
b. Existing		
1) Not damaged by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1 without primer	Match existing color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
9. Metal Stairs, Ladders, Platforms, and Supports Except Tread and Grating		
a. Interior	Uncoated	
b. Exterior	Uncoated	
c. Existing		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Interior	Uncoated	
b) Exterior	Uncoated	
10. Aluminum Flashing, Light Standards, Supports, and Louvers		
a. Interior and exterior, unless otherwise specified	Uncoated	--
11. Precast Concrete Metalwork		
a. Fasteners, anchors, supports, etc.	EU-1	Match wall
12. Other		
a. Fire hydrants	EU-1	FS 21302 Red
b. Flap gates	EA-1	Beige
c. Aluminum slide gates	Uncoated	--
d. Sluice gates		
1) Gate	--	--
2) Stem, except potable	G	--
3) Operator		
a) Interior	E-2	Note 2
b) Exterior	EU-1	Note 2
e. Tanks - refer to 09 96 00 (or 09 97 00)		
f. Pipe, ductwork, equipment and appurtenances made from fiberglass, plastic, rubber, including flexible hose, conduit, and plastic coated tubing, in areas not exposed to view (interior) (metal hangers and supports are coated with E-1)	Uncoated	--
g. Buried, sleeve-type and flanged pipe, couplings, valves, mechanical and electrical penetrations	M-1 or M-2	Manufacturer's color
Fluoride Building		
1. Interior		
h. Floors	EFL-2	Note1

Notes:

1. *Owner will select color from coating manufacturer's list of EPA approved colors for potable water.*
2. *Owner to select color from coating manufacturer's full range of standard colors.*
3. *Recoat existing equipment to provide a uniform appearance. Color shall remain the same unless otherwise noted in the Contract Documents.*

3.07 QUALITY ASSURANCE INSPECTION

A. General:

1. Inspection by the Owner or others does not limit the Contractor's or CSA's responsibilities for quality workmanship or sole responsibility for QC as specified by this Section or as required by the CSM's instructions. Inspection by the Owner is optional and is additional to any inspection required to be performed by the Contractor.
2. The Owner may perform, or contract with an inspection agency to perform, QA inspection and testing of the coating work covered by this Section. These inspections may include the following:
    a. Inspect materials upon receipt to ensure that all are supplied by the same CSM.
    b. Inspect to verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
    c. Inspect and record findings for the degree of cleanliness of substrates.
    d. Inspect and record the pH of concrete and metal substrates.
    e. Inspect and record substrate profile (anchor pattern).
    f. Measure and record ambient air and substrate temperature.
    g. Measure and record relative humidity.
    h. Check for the presence of substrate moisture in the concrete.
    i. Inspect to verify that correct mixing of coating system materials is performed in accordance with CSM's instructions.
    j. Inspect, confirm, and record that the "pot life" of coating system materials is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
    k. Perform adhesion testing.
    l. Measure and record the thickness of the coating system.
    m. Inspect to verify proper curing of the coating system in accordance with the CSM's instructions.
    n. Limited visual observations for defects.

3.08 FINAL INSPECTION

A. General
1. Contractor shall conduct a final inspection to determine whether coating system work meets the requirements of the specifications.
2. The Construction Manager or Owner's Representative will subsequently conduct a final observation with the Contractor to observe the completed work.
3. Any obvious defects or non-conforming work shall be marked. Such areas shall be recleaned and repaired as specified at no additional cost to the Owner.

PART 4 PROJECT QUALITY CONTROL CHECKLIST

09 90 00-A COATING SYSTEM QUALITY CONTROL CHECKLIST

Project Name

Owner		**Coating System Manufacturer Technical CTR**	
General Contractor (GC)		**Coating System Applicator (CSA)**	
Area or Structure		**Location within Structure**	
Coating System (e.g., E-1)		**Coating Type (e.g., Epoxy, etc.)**	

Coating System Quality Control Checklist

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
1	Completion of cleaning and substrate decontamination prior to abrasive blast cleaning.	Visual Inspection- Contaminant Free	GC QC			
		ASTM F22 – Concrete-Contaminant Free	CTR QC			
		Blacklight Testing- Contaminant Free	CSA QC			
2	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	As Per SSPC Guide 6	GC QC			
		As per Specification	CTR QC			
			CSA QC			
3	Ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	Negative Pressure in Enclosures	GC QC			
		Testing Every 2 hrs Minimum	CTR QC			
		Substrate temp 5°above the dewpoint and stabilized.	CSA QC			
4	Ensuring compressed air for abrasive blasting or coating/lining application is free of oil and moisture	ASTM D4285- Free of all oil & moisture	GC QC			
		1 blotter test per 2 hrs of compressed air usage	CTR QC			
			CSA QC			
5	Completion of Surface Preparation for Substrates to Be Coated. (Steel & Concrete)	Compliance with Sited SSPC/NACE Standards	GC QC			
		Compliance with Specification	CTR QC			
			CSA QC			
	Steel- Dust Level Testing- After surface preparation and prior to application of primers/coatings	ISO 8502-3 (Part 3)	GC QC			
		Dust Rating-1	CTR QC			
		Dust Particle Size - 0	CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
6	Soluble Chloride Testing (If needed) as per SSPC-Guide 15 (Steel Only)	AS Per CTR allowable limits per product.	GC QC			
			CTR QC			
			CSA QC			
7	Completion of Concrete Repairs If Required and Related Surface Preparation Rework Prior to Coating System Application.	Compliance with Specification	GC QC			
			CTR QC			
			CSA QC			
8	Completion of Concrete Filler/ Surface Application to Concrete.	Bughole/Void Free	GC QC			
		Flush with Existing Surface	CTR QC			
			CSA QC			
9	Completion of Primer Application.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
10	Completion of intermediate Coat Application and of Detail Treatment at Transitions or Terminations.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
11	Completion of Finish Coat Application and of Detail Treatment at Transitions and Terminations.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
12	Completion of Full and Proper Cure of Coating System.	ASTM D5402- Solvent Based Materials - No material transfer-	GC QC			
		Visual Inspection-Defect Free	CTR QC			
			CSA QC			
13	Completion of Testing of Cured Coating System including Adhesion, Holiday (Continuity) Testing and Dry Film Thickness.	ASTM D5402- Solvent Based Materials - No material transfer-	GC QC			
		Visual Inspection-Defect Free	CTR QC			
		As per Specification	CSA QC			
14	Completion of Localized Repairs to Coating System Following Testing.	Visual Inspection-Defect Free	GC QC			
			CTR QC			
			CSA QC			
15	Final Acceptance of Coating System Installation Including Final Clean-Up Complying	Visual Inspection-Defect Free	GC QC			
			CTR QC			
			CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	with Specification Requirements and the CTR's Quality Requirements.					

END OF SECTION

SECTION 09 96 00

HIGH PERFORMANCE PROTECTIVE COATINGS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This Section specifies coating systems, surface preparation, and application requirements for high performance protective coating systems applied to both concrete and metal substrates.

B. This section includes coatings systems for:
   1. Surfaces exposed to corrosive chemicals including various acids, sodium hydroxide, sodium hypochlorite, ferric chloride, hydrofluorosilicic acid, and sodium bisulfite, etc. whether vapor or immersion exposure.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 11 80 Environmental Conditions
   2. Section 01 33 00 Submittal Procedures
   3. Section 01 45 00 Contractor Quality Control
   4. Section 01 45 23 Testing and Inspection Services
   5. Section 01 61 45 Area Exposure Designations
   6. Section 01 66 00 Product Storage and Handling
   7. Section 01 99 00 Reference Forms
   8. Section 07 11 13 Bituminous Damproofing
   9. Section 09 90 00 General Coating Specification
   10. Section 09 97 00 Potable Protective Coatings

1.03 DEFINITIONS:

A. Coating terminology used in this Section is in accordance with definitions contained in ASTM D16, ASTM D3960, and the following definitions.
   1. Abrasive: Material used for blast cleaning, such as sand, grit or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. AMPP: Association for Materials Protection and Performance (Merger of NACE and SSPC).
   4. Anchor Pattern: Profile or texture of prepared surface(s).
   5. ANSI: American National Standards Institute.
   6. Bugholes: Small cavities, usually not exceeding 15 millimeters in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.

7. Biogenic Sulfide Corrosion: Sulfuric acid corrosion of metal and concrete substrates caused by the formation of sulfuric acid by the metabolic process of sulfurs oxidizing bacteria metabolizing hydrogen sulfide.
8. Coating/Paint/Lining Thickness: The total thickness of primer, intermediate and/or finish coats.
9. Coating System Applicator (CSA): A generic reference to the specialty subcontractor or subcontractors retained by the Contractor to install the coating systems specified in this Section.
10. Coating System Manufacturer (CSM): Refers to the acceptable coating system manufacturer, abbreviated as the CSM.
11. Coating System Manufacturer's Technical Representative(s) (CTR): Refers to the technical representative(s) of the acceptable Coating System Manufacturer and is abbreviated as CTR.
12. Continuous film or continuity of film: refers to coating layer/system without holidays, pinholes or other discontinuities.
13. CQC: Coating System Applicator (CSA) Quality Control.
14. Dehumidification: The removal of moisture, humidity or dampness from the air
15. Dew point: Temperature of a given air/water vapor mixture at which condensation starts.
16. Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001 inch).
17. Drying/Cure Time: Time interval between application and curing of material before exposure to service conditions.
18. Dry to Recoat: Time interval between application of material and ability to receive next coat.
19. Dry to Touch: Time interval between application of material and ability to touch lightly without damage.
20. Feather Edging: Reducing the thickness of the edge of paint.
21. Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.
22. Field Coat: The application or the completion of application of the coating system after installation of the surface at the site of the work.
23. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
24. Holiday: A discontinuity, skip, or void in coating or coating system film that exposes the substrate.
25. Honeycomb: Segregated condition of hardened concrete due to non-consolidation
26. ICRI: International Concrete Repair Institute.
27. Incompatibility: Inability of a coating to perform well over another coating because of bleeding, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.
28. Laitance: A layer of weak, non-durable concrete containing cement fines that are brought to the surface through bleed water because of concrete finishing and/or over-finishing.
29. Mil: 0.001 inch.
30. NACE: National Association of Corrosion Engineers.
31. NSF International: National Sanitation Foundation.

32. Overspray: Dry spray, particularly such paint that failed to strike the intended surface.
33. Owner's Quality Assurance Representative: Person or persons designated by the Owner to perform QA review of the Contractor's QC reports and inspection and testing work.
34. Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.
35. Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.
36. QCP: Quality Control Person representing the Contractor and responsible for QC Testing, Inspection and associated documentation.
37. QCTIP: Quality Control Testing and Inspection Plan.
38. QP-1 AMPP: Accredited program that evaluates the practices of field painting.
39. QP-3- AMPP: Accredited program that evaluates the practices of shop painting facilities.
40. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-base material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
41. Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.
42. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.
43. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
44. SSPC: The Society for Protective Coatings.
45. Stripe Coat: A separate coat of paint applied to all weld seems, pits, nuts/bolts/washers and edges by brush. This coat shall not be applied until any previous coat(s) have cured and once applied, shall be allowed to cure prior to the application of the subsequent coat(s).
46. Surface Saturated Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
47. Tie Coat: An intermediate coat used to bond different types of paint coats; coatings used to improve the adhesion of a succeeding coat.
48. Touch-Up Coating: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
49. TPC: Technical Practice Committee.
50. Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).
51. Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in water or wastewater at least intermittently if not constantly.
52. Weld Spatter: Beads of metal scattered near seam during welding.
53. Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application; wet film thickness is measured in mils or thousandths of an inch (0.001 inch) and is abbreviated WFT.

1.04 REFERENCES:

A. This section contains references to the following documents listed and described below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed and described documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

References	Title
ANSI/ASC 29.4 Exhaust Systems	Abrasive Blasting Operations – Ventilation and Safe Practice
ANSI B74.18	Grading of Certain Abrasive Grain on Coated Abrasive Material
ASTM C1583	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)
ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
ASTM D2200 (SSPC-VIS1)	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings On Metal Substrates Using Portable Adhesion Testers
ASTM D4787	Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates
ASTM D5162	Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
ASTM 5402	Standard Practice for assessing the solvent resistance of organic coatings using solvent rubs
ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers.
ASTM E337	Standard Test Method for Measuring Humidity With a Psychrometer
ASTM F22	Standard Test Method for Hydrophobic Surface Films by the Water-Break Test

References	Title
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2170	Standard Test Method for Measuring Relative Humidity in Concrete Floor Slabs Using Insitu Probes.
FS 595b	Federal Standard Colors
ICRI 310.2R-2013	Guideline for Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair
ISO 8502-3 (Part 3)	Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method)
NACE Publication 6D-163	A Manual for Painter Safety
NACE Publication 6F-163	Surface Preparation of Steel or Concrete Tank/Interiors
NACE Publication 6G-164 A	Surface Preparation Abrasives for Industrial Maintenance Painting
NACE Standard RP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE Standard RP0288	Standard Recommended Practice, Inspection of Linings on Steel and Concrete
NACE SP0178	Design, Fabrication and Surface Finish Practices for Vessels and Tanks to Be Lined for Immersion
NACE Standard RP0892	Standard Recommended Practice, Linings Over Concrete in Immersion Service
NACE Publication TPC2	Coatings and Linings for Immersion Service
NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
NAPF 500-03-04	Abrasive Blast Cleaning for Ductile Iron Pipe
NAPF 500-03-05	Abrasive Blast Cleaning for Cast Ductile Iron Fittings
OSHA 1910.144	Safety Color Code for Marking Physical Hazards
OSHA 1915.35	Standards – 29CFR – Painting
South Coast Air Quality Management District (SCAQMD)	Rule 1113 -Architectural Coatings
SSPC	Paint Application Specification No. 1.
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC Guide 15	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC-PA Guide 3	A Guide to Safety in Paint Application
SSPC-PA Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
SSPC PA-Guide 10	Guide to Safety and Health Requirements for Industrial Painting Projects
SSPC- PA Guide 11	Guide for Stripe Coating
SSPC-PA Guide 12	Guide for Illumination of Industrial Painting Project
SSPC SP1	Solvent Cleaning
SSPC SP2	Hand Tool Cleaning
SSPC SP3	Power Tool Cleaning
SSPC SP5/NACE #1	White Metal Blast Cleaning
SSPC SP6/NACE#3	Commercial Blast Cleaning
SSPC SP7/NACE #4	Brush-Off Blast Cleaning
SSPC SP10/NACE#2	Near-White Blast Cleaning

References	Title
SSPC SP11	Power Tool Cleaning to Bare Metal
SSPC SP WJ-1/NACE WJ-1	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Clean to Bare Substrate
SSPC SP WJ-2/NACE WJ-2	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Very Thorough Cleaning
SSPC SP WJ-3/NACE WJ-3	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Thorough Cleaning
SSPC SP WJ-4/NACE WJ-4	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Light Cleaning
SSPC SP13/NACE#6	Surface Preparation of Concrete
SSPC SP14/NACE#8	Industrial Blast Cleaning
SSPC SP15	Commercial Power Tool Cleaning
SSPC SP16	Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
SSPC SP-CAB 1	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Thorough Cleaning
SSPC SP-CAB 2	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Intermediate Cleaning
SSPC SP-CAB 3	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Brush Blast Cleaning
AMPP SP21548	Pressurized Water Cleaning of Concrete and Cementitious Materials- Thorough Cleaning
SSPC-TR2	Wet Abrasive Blast Cleaning
SSPC-TU-3	Overcoating
SSPC-TU-4	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC V2	Systems and Specifications: Steel Structures Painting Manual, Volume 2
SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
SSPC-VIS 4	Visual Standards (Water-jetting)
SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)

1.05 QUALITY ASSURANCE

A. General Requirements:

1. Provide materials and supplies provided that are standard products of CSMs. Provide materials in each coating system from a single CSM.
2. The standard products of CSMs other than those specified may be acceptable when it is demonstrated to the Construction Manager that they are equal in composition, durability, usefulness, and convenience for the purpose intended. Requests for consideration of CSMs other than those specified in this Section will be considered in accordance with the requirements of the General Conditions and provided the following minimum conditions are met. Such requests are not a substitution for submittals after the alternative CSMs have been considered and accepted.
    a. The proposed coating system uses an equal or greater number of separate coats to achieve the required total DFT.
    b. The proposed coating system uses coatings of the same generic type as that specified including curing agent type.

c. Include information listed in paragraph 1.07, demonstrating that the proposed CSM's product is equal to the specified coating system.

d. Provide a list of Contractor and CSM references for the proposed product where the coating of the same generic type has been applied. Include the project name, city, state, owner, and phone number of owner; coating system reference and number from this Section 09 96 00; type of facility in which it was used, generic type, and year coating was applied.

e. At any time when there is a conflict between the CSM's product data and the COATSPEC requirements regarding surface preparation, material application or any other coating details that provides the more stringent requirements will take precedent.

B. Shop and Field Quality Control Requirements:

1. The Contractor is solely responsible for the workmanship and quality of the coating system installation by the CSA. Inspections by the Owner, Engineer, a Construction Manager, the CTR, or any other party will not relieve or limit the Contractor's responsibilities for the quality of the coating system.
2. Conform to requirements of this specification and the standards referenced in this Section. Changes in the coating system installation requirements will be allowed only with the written acceptance of the Engineer before work commences.
3. Only personnel who are trained by the CTR specifically for this contract or who are approved by the CSM specifically for this contract shall be allowed to perform the coating system installation specified in this Section.
4. Perform all field surface preparation and coating applications by a AMPP QP8 Certified field painting Contractor in good standing for all concrete applications, and AMPP QP-1 for all applications on surfaces other than concrete. Should the contractor working on concrete substrates not have an AMPP QP-8 certification, the QP-1 contractor certification may be acceptable providing the QP-1 contractor can show verifiable proof of performing work successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.
5. Perform all shop surface preparation and coating applications by a AMPP QP3 Certified blast and painting shop in good standing.
6. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
7. For repairs, provide the same products, or products recommended by the CSM, as used for the original coating.
8. Identify the points of access for inspection by the Owner, the Engineer, or the Owner's Representative. Provide ventilation, ingress and egress, and other safe means necessary for the Owner's or Engineer's personnel or designated representative to safely access the work areas.
9. Contractor and CSA to conduct the work so that the coating system is installed as specified and inspect the work continually to ensure that the coating system is installed as specified. Correct coating system work that does not conform to the specifications or is otherwise not acceptable to the as-specified requirements.
10. Provide full time inspection with trained and certified quality control (QC) inspectors performing all QC procedures as the coating work proceeds in accordance with the requirements of this section. Minimum qualifications for QC inspectors on concrete projects are AMPP-CCI Level 1 with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified

CCILevel 2 Concrete Coatings Inspector. On non-concrete related project, the minimum QC inspector is AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience. An AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience may be acceptable providing the AMPP Basic, AMPP Certified and AMPP Senior coating inspectors can each can show verifiable proof of performing inspection successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.

11. Submit for approval a Quality Control Testing and Inspection Plan (QCTIP) for the work covered by this Section. List all tests and inspection tasks in the QCTIP including referenced and applicable standards to be conducted and the frequency in which these tests or tasks will be performed. This frequency can be addressed for certain tests such as air and substrate temperature or Dew Point measurements on an hourly per shift basis. Or this frequency can be addressed on a per number of square feet basis for tests and tasks such as WFT and DFT tests or adhesion tests. Include in the QCTIP a written record which identifies when (time and date) work not conforming to the specification requirements is identified a written record of the proposed corrective actions for such non-conforming work and a record of when that action was performed (time and date). Describe all corrective action for non-conforming work in detail with referenced digital photographs taken of that re-work.
12. Submit a daily QC inspection report from the QCP that describes and documents all QC tests and inspection tasks performed including frequency of performance and test results (including test data) and referenced standard followed for each shift the Contractor works. Submit these reports on the morning of the following day the work was performed to the Construction Manager. Include with the daily QC report, a written account of all non-conforming work, subsequent corrective measures and annotated digital photographs of such work. Submit a standard inspection form to be used for these reports for review by the Engineer. The approved inspection report forms shall be used by the Contractor's QC Inspector to record all QC inspection and testing throughout the performance of the coating work.
13. The CSA, with Contractor's oversite, shall complete the COATING SYSTEM QUALITY CONTROL CHECKLIST, see 3.12 Form 09 90 00-A, included in 01 99 90, for coating system installations. Follow the sequential steps required for proper coating system installation as specified and as listed in the COATING SYSTEM QUALITY CONTROL CHECKLIST. For each portion of the work, install the coating system and complete sign-offs as specified prior to proceeding with the next step. After completing each step as indicated on the COATING SYSTEM QUALITY CONTROL CHECKLIST, the Contractor shall sign the checklist indicating that the work has been installed and inspected as specified.

C. Quality Control Hold Points:
    1. Conduct QC inspections per the QCP as the coating work progresses, including surface preparation. In addition, conduct inspection at Hold Points with sign off by all involved parties (GC, CSA, CSM) on the project Quality Control Checklist, Form 09 96 00-A. QC inspections and testing shall be performed as often as needed to ensure

full compliance to this specification. Coordinate schedule of all Hold Points with the CTR, Engineer and Construction Manager so they may observe the QC inspections. The minimum QC inspection Hold Points include but are not limited to the following:

a. Environment and Site Conditions: Prior to commencing an activity associated with coating system installation, measure and record ambient air temperature and humidity as well as other conditions such as proper protective measures for surfaces not to be coated and safety requirements for personnel. Confirm weather and/or environmental conditions within the structure comply with the requirements specified by the CSM.

b. Conditions Prior to Surface Preparation: Prior to commencing surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts have been eliminated from the surface.

c. Monitoring of Surface Preparation: Spot check degree of cleanliness, surface profile, and surface pH testing, where applicable. Confirm the compressed air used for surface preparation or vacuum or wash-down cleaning is free from oil and moisture.

d. Post Surface Preparation: Upon completion of the surface preparation, measure and inspect for proper degree of cleanliness and surface profile as specified in this Section and in the CSM's written instructions.

e. Ensure any remaining dust meets acceptable level of the specification requirements after surface preparation and prior to the application of primer and coatings.

f. Monitoring of Coatings Application: Inspect, measure, and record the WFT and general film quality (visual inspection) for lack of runs, sags, pinholes, holidays, etc. as the application work proceeds.

g. Post Application Inspection: Identify defects in application work including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems as may be observed.

h. DFT Measurements: Take DFT measurements after each coat and record them in the daily QC inspection reports. Take DFT readings for steel surface in accordance with SSPC- PA2 using Type II Magnetic DFT Gauges for ferrous surfaces and Type II Eddy Current Gauges for non-ferrous surfaces. DFT readings for concrete surface may be taken as per SSPC- PA9 using Ultra Sonic DFT Gauges or by proving materials usage versus square foot coverage. Use only gauges calibrated by the manufacturer or approved agent within 1 year of use. Following SSPC- PA2 and SSPC-PA9, take as many DFT measurements necessary, which may exceed the SSPC-PA2 and SSPC-PA9 to ensure full compliance to this specification.

i. Post Cure Evaluation: Measure and inspect the overall DFT, conduct a DFT survey, perform adhesion testing, holiday detection, or cure testing as required based on the type of project and the specific requirements in this Section and/or in the CSM's written instructions.

j. Follow-up to Corrective Actions and Final Inspection: Measure and reinspect corrective coating work performed to repair defects identified at prior Hold Points. Includes final visual inspection along with follow-up tests such as holiday detection, adhesion tests, and DFT surveys.

D. Quality Assurance Inspection:

1. The Owner and Engineer reserve the right to retain the services of a Quality Assurance Inspection firm to perform random audits of the CSA's QC processes and documentation at any time during the project's progress including the various Hold Points. Any inspections by the Owner, Engineer, or other owner related representatives do not relieve the Contractor from having sole responsibility for the quality of the installed coating system.
2. Coordinate Hold Points with the Owner's Quality Assurance representative such that this representative may observe the CSA's QC inspections on a scheduled basis. Provide the Owner's Quality Assurance representative a minimum of 48 hours' notice prior to conducting Hold Point Inspections.

E. Responsibilities of the CTR:
   1. General:
      a. Provide the services of the CTR to be on site to perform the Contractor and/or CSA application training and to routinely verify in writing that the application personnel have successfully performed representative portions of the surface preparation work, filler/surface application, coating system application, and QC Inspection in accordance with this Section. Include testing, checking, or witnessing the contractors testing for the required degree of cleanliness, surface pH for concrete substrates, surface profile of substrates, proper mixing of coating materials, application (including checking the WFT and DFT of the coating systems), proper cure of the coating systems, and proper treatment of coating systems at terminations, transitions, and joints and cracks in substrates. This verification is in addition to the inspection performed by the Contractor in accordance with this Section. The CTR must be a technical representative of the CSM's Technical Service Department and not a local sales representative. The CTR shall provide an adequate level of oversight of the contractor's QC processes, at their discretion, to provide sign off that the CSM's products have been properly installed.
   2. Coating System Installation Training:
      a. Provide a minimum of 8 hours of classroom and off-site training for application and supervisory personnel of the Contractor (CSA). Provide training to a minimum of 2 supervisory personnel from the CSA. Alternatively, provide a written letter from the CSM stating that the application personnel (listed by name) who will perform coating work are approved by the CSM without further or additional training.
      b. The same CTR shall provide training for all application and supervisory personnel. Include the following as a minimum:
         1) A detailed explanation of mixing, application, curing, and termination details.
         2) Hands-on demonstration of how to mix and apply the coating systems.
            a) A detailed explanation of the ambient condition requirements (temperature and humidity) and surface preparation requirements for application of the coating system as well as a detailed explanation of re-coat times, cure times, and related ambient condition requirements.
         3) Provide a letter stating that training was satisfactorily completed by the personnel listed by name in the letter.
   3. Representative Coating System Inspections:
      a. While on site to verify or witness the QC processes of the contractor, the CTR shall verify representative steps of the coating work are performed properly per

the manufacturer's instructions, the CTR shall coordinate and confirm the planned inspections by the Contractor's QC person are being performed per the QCTIP to assure quality of the work meets the requirements of both these specifications and any additional manufacturer's requirements

b. The CTR shall verify or witness the following QC processes, at their discretion and as delineated above in 1.05.C.
   1) Inspect ambient conditions during various coating system installation at hold points for conformance with the specified requirements.
   2) Inspect the surface preparation of the substrates where the coating system will terminate or will be applied for conformance to the specified application criteria.
   3) Inspect preparation and application of coating detail treatment (for example, terminations at joints, metal embedments in concrete, etc.).
   4) Inspect application of the filler/surface materials for concrete and masonry substrates.
   5) Inspect application of the primers and finish coats including WFT and DFT of the coatings.
   6) Inspect coating systems for cure.
   7) Review adhesion testing of the cured coating systems for conformance to specified criteria.
   8) Review coating system discontinuity testing for conformance to specified criteria.
   9) Observe adhesion testing work to assure it meets specification requirements.
   10) Inspect and record representative localized repairs made to discontinuities identified via continuity testing.
   11) Conduct a final review of completed coating system installation for conformance to the specifications.

c. Prepare and submit a site visit report following each site visit that documents the acceptability of the coating work observed and inspected in accordance with the CSM's Recommendations.

4. Final Report:
   a. Upon completion of coating work for the project, the CTR shall prepare a letter summarizing the inspection findings and shall attach the site visit reports required in 1.05. Include a statement that the completed work was performed in accordance with the requirements of this Section 09 96 00 and the CSM's recommendations based on the inspections performed by the CTR.

1.06 DELIVERY AND STORAGE

A. General:
   1. Conform to the requirements of Section 01 66 00, Product Storage and Handling Requirements.
   2. Deliver materials to the job site in their original, unopened containers. Properly label each container shall be properly labeled. Handle and store to prevent damage to or loss of label.
   3. Include the following information on material container labels:

a. Name or title of product
b. CSM's batch number
c. CSM's name
d. Generic type of material
e. Application and mixing instructions
f. Hazardous material identification label
g. Shelf life expiration date

4. Store materials in enclosed structures protected from weather and excessive heat or cold in accordance with the CSM's recommendations. Store flammable materials in accordance with state and local requirements.
5. Clearly mark containers indicating personnel safety hazards associated with the use of or exposure to the materials.
6. Provide Safety Data Sheets (SDS) for each material to the Construction Manager, Owner, Contractor, and CSA.
7. Store and dispose of hazardous waste including waste solvents and coatings according to federal, state and local requirements.

1.07 SUBMITTALS:

A. Action Submittals:
1. Procedures: Section 01 33 00.
2. A copy of this specification section, with addendum updates included, and referenced and applicable sections, with addendum updates included, with each paragraph check-marked (☐) to indicate specification compliance or marked to indicate requested deviations from specification requirements or those parts which are to be provided by the Contractor or others. Check marks denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph, provide a detailed explanation of the reasons for requesting the deviation. Engineer is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined signifies compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations to the specification requirements, is cause for rejection of the entire submittal and no further submittal material will be reviewed.
3. CSM's current printed recommendations and product data sheets for coating systems including:
a. Volatile organic compound (VOC) data
b. Surface preparation recommendations
c. Primer type, where required
d. Maximum dry and wet-mil thickness per coat
e. Minimum and maximum curing time between coats, including atmospheric conditions for each
f. Curing time before submergence in liquid
g. Thinner to be used with each coating

h. Ventilation requirements
i. Minimum atmospheric conditions during which the paint shall be applied
j. Allowable application methods
k. Maximum allowable moisture content
l. Maximum shelf life

4. Affidavits signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements.
5. Safety Data Sheets (MSDS) for materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.
6. Written list of cleaning and thinner solutions allowed by the CSMs.
7. Storage requirements including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
8. CSM's detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including pipe penetrations, metal embedments, gate frames, and other terminations to be determined from the contract drawings. Include detail treatment for coating system at joints and cracks in concrete.
9. Provide a minimum of 5 project references each for the Contractor and CSA including contact name, address, and telephone number where similar coating work has been performed by their companies in the past 5 years.
10. Written certification that the Contractor's QC person for the work is a Certified SSPC or NACE Coatings Inspector with the requisite experience identified in 1.05.B.8.
11. Written Quality Control Testing and Inspection Plan (QCTIP) for the coating work covered by the Contract for this project and as specified in this Section.
12. Sample Daily QC Inspection Report Forms to be used by the Contractor's QC person assigned to the work covered by this Section.
13. Written letter from CSM signed by a Company officer that the Contractor's personnel who will perform the coating work have successfully been trained to apply the specified and approved coating materials.
14. Signed Affidavit from CSM that all products provided for the coating work covered by this Section are compliant with applicable VOC regulations.
15. Completed, signed and dated Quality Control Checklists.

B. Informational Submittals:
1. Procedures: Section 01 33 00.
2. Prior to application of coatings, submit letter(s) from the CTR(s) identifying the application personnel who have satisfactorily completed training as specified in article 1.05 or a letter from the CSM stating that personnel who shall perform the work are approved by the CSM without need for further or additional training.
3. Submit reports specified in article 1.05. while the work is underway.

C. Closeout Submittals:
1. Procedures: Section 01 33 00.
2. Submit the COATING SYSTEM QUALITY CONTROL CHECKLIST using Form 09 96 00-A, included in this Section, for the coating work.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Notwithstanding the listing of product names in this Section, provide affidavits, signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements. Do not apply coatings until the specified affidavits have been submitted and reviewed and accepted. Failure to comply with this requirement is cause for rejection and removal of such materials from the site.
2. Coating Systems are designated as "HP" for general high performance systems used in various treatment plant, and industrial applications, corrosive environments, and moisture vapor transmission suppression systems, and "SC" for use in secondary containment associated with specific corrosive chemicals.

B. Description of Standard High Performance Coating Systems. The list below provides, for each system, a brief description of the coating material, appropriate substrate and exposure. For the specific Finish Schedule, refer to Section 09 90 00 Article 3.08.

Coating systems Designation	Description
HP-1	Not used
HP-2	Not used
HP-3	Not used
HP-4	Not used
HP-5	Not used
HP-6	Not used
HP-7	Not used
HP-8	Not used
HP-9	Not used
HP-10	Not used
HP-11	Not used
HP 12	Moisture Vapor Transmission (MVT) Suppression System for Use Under Tank Linings on Concrete. (Unlimited MVT Resistance)
HP-13	Moisture Vapor Transmission Suppression System for Use Under Tank Linings on Concrete. (up to 20 lbs/1000 Sq/24 hrs.) as Per ASTM F1869
HP-14	Moisture Vapor Transmission Suppression System for Use Under Tank Linings on Concrete. (up to 10 lbs/1000 Sq/24 hrs.) as Per ASTM F1869
SC-1	Not used
SC-2	Not used
SC-3	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester- Secondary Containment for 12.5% Sodium Hypochlorite

Coating systems Designation	Description
SC-4	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester- Secondary Containment for 25% Hydrofluorosilicic Acid
SC-5	Not used
SC-6	Not used
SC-7	Not used
SC-8	Not used
SC-9	Not used
SC-10	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester- Secondary Containment for 50% Ferric Chloride
SC-11	Not used
SC-12	Not used
SC-13	Not used
SC-14	Not used
SC-15	Not used
SC-16	Not used
SC-17	Not used
SC-18	Not used
SC-19	Not used
SC-20	Not used
SC-21	Not used
SC-22	Not used
SC-23	Not used
SC-24	Not used
SC-25	Not used
SC-26	Not used

C. Material Requirements for Standard High Performance Coating Systems. The table below provides, for each system, acceptable Coating System Manufacturers and products for each coat.

Material Requirements for Standard Coating Systems for United States and Canada, except for California SCAQMD:

Coating Systems Designation	CSM	Pit Filler/Mortar Repair	Primer/Intermediate Coats	Finish Coats
HP-1	Carboline	Carboguard 501	Plasite 4500S	Plasite 4500S
	Sauereisen	#209 Filler	Conoweld 501	Sewergard 210X
	Sherwin Williams	Steel Seam FT 910	Dura-Plate UHS	Dura-Plate UHS
	Tnemec Company	Series 215 Filler	Perma-Glaze G435	Perma-Glaze G435

Material Requirements for Standard Coating Systems for United States and Canada, except for California SCAQMD:

Coating Systems Designation	CSM	Pit Filler/Mortar Repair	Primer/Intermediate Coats	Finish Coats
HP-2	Carboline	Carboguard 501	Carboguard 890 (2 coats)	Carbothane 134VOC
	Sauereisen	#209 Filler	Conoweld 510-Primer x 1C Sewergard 210X- Inter x 1C	Conothane 310
	Sherwin Williams	Steel Seam FT 910	Macropoxy 5500LT 9 (1-2 Coats)	High Solids Polyurethane 250
	Tnemec Company	Series 215 Filler	Epoxoline 141	Endurashield II Series 1075
HP-3	Carboline	Carboguard 510	Carboguard 690 (Optional)	Plasite 4500S (2 coats may be required)
	Sauereisen	Series #208 Series F120 or F121	PenePrime 500 (optional)	Sewergard 210X
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Macropoxy 5000 (Optional)	Cor-Cote FRE
	Tnemec Company	Series 218 Series 217	Series 201 (optional)	Perma-Shield G436
HP-4	Carboline	Carboguard 510	Carboguard 690 (Optional)	Plasite 4500S
	Sauereisen	Series #208 Series F120 or F121	ConoPrime 502 (optional)	Sewergard 210X
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Macropoxy 5000 (Optional)	Cor-Cote FRE
	Tnemec Company	Series 218 Series 217	Series 201 (optional)	Perma-Shield G436
HP-5	Carboline	Carboguard 501	Plasite 4500S	Plasite 4500S
	Sauereisen	#209 Filler	Conoweld 501	Sewergard 210X
	Sherwin Williams	Steel Seam FT 910	NA	Cor-Cote FRE
	Tnemec Company	Series 215 Filler	NA	Perma-Shield G436
HP-6	Carboline	Carboguard 510	NA	Plasite 5371
	Sauereisen	Series #208 Series F120 or F121	Series 210T	Series 210X (Seal Coat)
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	NA	Dura-Plate 5900 Mortar
	Tnemec Company	Series 218 Series 217	NA	Perma-Shield 434
HP-7	Carboline	Carboguard 501	Phenoline Tank Shield FP	Plasite 4500S
	Sauereisen	#209 Filler	Conoweld 501	Sewergard 210X
	Sherwin Williams	Steel Seam FT 910		Cor-Cote FRE
	Tnemec Company	Series 215 Filler	NA	Perma-Shield G436
HP-8	Carboline	Carboguard 501	Phenoline Tank Shield FP	Plasite 4500S
	Sauereisen	Series #208 Series F120 or F121	ConoPrime 502 (optional)	Sewergard 210X

Material Requirements for Standard Coating Systems for United States and Canada, except for California SCAQMD:

Coating Systems Designation	CSM	Pit Filler/Mortar Repair	Primer/Intermediate Coats	Finish Coats
	Sherwin Williams	Steel Seam FT 910	Macropoxy 5000 (Optional)	Cor-Cote FRE
	Tnemec Company	Series 218 Series 217	Series 201 (optional)	Perma-Shield G436
HP-9	Carboline	Carboguard 501	Phenoline Tank Shield FP	Plasite 4500S
	Sauereisen	#209 Filler	#560 High Temp	Series 210GN (Multiple Coats)
	Sherwin Williams	Steel Seam FT 910	Dura-Plate 8200	Dura-Plate 8200
HP-10	Carboline	Carboguard 501	Phenoline Tank Shield FP	Plasite 4500S
	Sauereisen	Series F120 or F121	NA	Series 210TN
	Sherwin Williams	Steel Seam FT 910	Dura-Plate 8200	Dura-Plate 8200
HP-11	PPG	PPG Raven 760 EMC	Raven 175 Optional	Raven 405
	Sauereisen	Series F120 or F121	PenePrime 500 (optional)	Series 210XHB
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Macropoxy 5000 (Optional)	Dura-Plate 6100

Material Requirements for Standard Moisture Vapor Transmission (MVT) Suppression Coating Systems for United States and Canada, Except for California SCAQMD

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
*HP-12 UL MVT	PPG	Raven 760 EMC	Series 900 LVT at 12 mils	PPG Flooring Urethane Cement Cove Base at 3/16"	Broadcast 20/40 clean dry silica sand to rejection	The specified topcoat at the specified mils
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Resufloor Aqua 3477 at 2.0-4.5 mils	Fastop 4050 Slurry at 3/16"	Broadcast - 5310-8 Silica Sand (20-40 mesh) to saturation	The specified topcoat at the specified mils
*HP-13 <20 lbs. MVT	PPG	Raven 760 EMC	Series 912LV at 20 mils	NA	NA	The specified topcoat at the specified mils
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Resufloor Aqua 3477	Fastop 4050 Slurry at 3/16"	Broadcast - 5310-8 Silica Sand (20-40 mesh) to saturation	The specified topcoat at the specified mils
*HP-14 <10lbs MVT	Carboline	Carboguard 510 or Carboguard 4010	Vapor Stop at 10-15 mils	Vapor Stop at 10-15 mils	Vapor Stop at 10-15 mils	The specified topcoat at the specified mils
	PPG	Raven 760 EMC	Series 912LV at 10 mils	NA	NA	The specified topcoat at the specified mils
	Sherwin Williams	Dura-Plate 2300 AW Cook MSM	Resuprime MVT at16-20 Mils	NA	NA	The specified topcoat at the specified mils

**CSA shall contact the manufacture for specific application instructions and Technical Bulletin for Application Procedures*

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
SC-1 50% Sodium Hydroxide	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Duraplate UHS Laminate at 20 – 25 mils with 1 oz. fiberglass mat	Duraplate UHS Epoxy at 8 – 10 mils with 20/40 mesh aggregate broadcast	Duraplate UHS Epoxy at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	237SC Chembloc (neat) at 8-12 mils with /211-215 Mat	237 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 280 at 8-12 mils
SC-2 18% Sodium Hypochlorite	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Semstone Series 800 PM As required	Dudick 27 Primer at 8-10 mils	Semstone 870AFRC at 25-30 mils with Semstone scrim cloth	Semstone 870AFRC at 25-30 mils /20/40 Mesh Aggregate Broadcast	Semstone 870AFRC at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 8-12 mils
SC-3 12.5% Sodium Hypochlorite	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Semstone Series 800 PM As required	Dudick 27 Primer at 8-10 mils	Semstone 870AFRC at 25-30 mils with Semstone scrim cloth	Semstone 870AFRC at 25-30 mils /20/40 Mesh Aggregate Broadcast	Semstone 870AFRC at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 8-12 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-4 25% Hydrofluorosilicic Acid	Akzo Nobel	Ceilcote 6640B + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640B at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + B1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40	Semstone 145 at 15-20 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
					Mesh Aggregate Broadcast	
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 251SC Primer at 6 -12 mils	252 SC Mortar at 60-80 mils with 211-215 Mat	252 SC (Neat) at 8-12 mils	252 SC (Neat) at 8-12 mils
SC-5 56% Acetic Acid	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 251SC at 6-12 mils	Series 252 SC Mortar at 60-80 mils	Series 252 SC (neat) at 8-12 mils	Series 252 SC (neat) at 8-12 mils
SC-6 50% Aluminum Chlorohydrate	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 251SC at 6-12 mils	Series 252 SC (neat) at 60-80 mils with 211-215 Mat	Series 252 SC (neat) at 12-24 mils	Series 252 SC at 8-12 mils
SC-7 30% Aluminum Oxide	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Duraplate UHS Laminate at 20 – 25 mils with 1 oz. fiberglass mat	Duraplate UHS Epoxy at 8 – 10 mils with 20/40 mesh aggregate broadcast	Duraplate UHS Epoxy at 12 – 25 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	237 SC Chembloc (neat) at 8-12 mils with 211-215 Mat	237 SC Chembloc (neat) at 16-24 mils	Tneme Glaze Series 280 at 6-12 mils
SC-8 50% Citric Acid	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-9 100% Defoaming Solution	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc (neat) at 8-12 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-10 50% Ferric Chloride	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 8-12 mils
SC-11 12% Ferric Sulfate	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 8-12 mils
SC-12 25% Hydrogen Peroxide	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 251SC at 6-12 mils	Series 252 SC at 60-80 mils with 211-215 Mat	252 SC Chembloc (neat) at 12-24 mils	Series 252 SC at 8-12 mils
SC-13 34% Hydrogen Peroxide	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 251SC at 6-12 mils	Series 252 SC at 60-80 mils with 211-215 Mat	252 SC Chembloc (neat) at 12-24 mils	Series 252 SC at 8-12 mils
SC-14 50% Hydrogen Peroxide	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25	Resuflor 3741 at 8 – 10 mils with	Resuflor 3741 at 12 – 25 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
		needed for patch and fill)		mils with 1 oz. fiberglass mat	20/40 mesh aggregate broadcast	
	Tnemec Company	Series 1416 Resin + Series 211-9111 Bulking Powder	Series 1416-900 Vinester at 5-8 mils	Series 1416 Vinester Mortar at 40-50 mils with 211-226/227 Mat	Series 1416 Vinester Saturant at 20-30 mils	Series 1416 Vinester at 15-20 mils
SC-15 100% Methanol	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 8-12 mils
SC-16 15% Peracetic Acid	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	NA	NA	NA	NA	NA
SC-17 35% Peracetic Acid	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	NA	NA	NA	NA	NA
SC-18 75% Phosphoric Acid	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 8-12 mils
SC-19 30% Aluminum Chloride	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Duraplate UHS Laminate at 20 – 25 mils with 1 oz. fiberglass mat	Duraplate UHS Epoxy at 8 – 10 mils with 20/40 mesh aggregate broadcast	Duraplate UHS Epoxy at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	237 SC Chembloc (neat) at 8-12 mils with 211-215 Mat	237 SC Chembloc (neat) at 16-24 mils	Tneme Glaze Series 280 at 6-12 mils
SC-20 35% Sodium Bisulfite	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Semstone Series 800 PM As required	Dudick 27 Primer at 8-10 mils	Semstone 870AFRC at 25-30 mils with Semstone scrim cloth	Semstone 870AFRC at 25-30 mils /20/40 Mesh Aggregate Broadcast	Semstone 870AFRC at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-21 38% Sodium Bisulfite	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25	Resuflor 3741 at 8 – 10 mils with	Resuflor 3741 at 12 – 25 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
		needed for patch and fill)		mils with 1 oz. fiberglass mat	20/40 mesh aggregate broadcast	
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-22 93% Sulfuric Acid	Akzo Nobel	Series 680 + S1 Powder As required	Series 680 + C1 Powder As required	Series 800 Coroline at 60-80 mils/ Mat Reinforcement	NA	Series 2000 Flakeline at 15-25 Mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils
SC-23 98% Sulfuric Acid	Akzo Nobel	Series 680 + S1 Powder As required	Series 680 + C1 Powder As required	Series 800 Coroline at 60-80 mils/ Mat Reinforcement	NA	Series 2000 Flakeline at 15-25 Mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Series 1416 Resin + Series 211-9111 Bulking Powder	Series 1416-900 Vinester at 5-8 mils	Series 1416 Vinester Mortar at 40-50 mils with 211-226/227 Mat	Series 1416 Vinester Saturant at 20-30 mils	Series 1416 Vinester at 15-20 mils
SC-24 32% Urea Ammonium Nitrate	Akzo Nobel	Ceilcote 6640 + S1 Powder As required	Ceilcote 380 at 2-5 mils	Ceilcote 6640 at 32 mils/ Mat Reinforcement	NA	Ceilcote 6640 + S1 powder at 60 mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils

Material Requirements for Secondary Containment Systems for United States and Canada, except for California SCAQMD:

System	CSM	Step 1	Step 2	Step 3	Step 4	Finish Coat
	Tnemec Company	Manufacturers Filler Material as required.	Series 251SC at 6-12 mils	Series 252 SC Mortar at 60-80 mils with 211-215 Mat	252 SC Chembloc (neat) at 12-24 mils.	Series 252 SC at 8-12 mils
SC-25 40% Ammonium Sulfate	Akzo Nobel	Series 680 + S1 Powder As required	Series 680 + C1 Powder As required	Series 800 Coroline at 60-80 mils/ Mat Reinforcement	NA	Series 2000 Flakeline at 15-25 Mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resuflor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resuflor 3741 at 12 – 25 mils
	Tnemec Company	Manufacturers Filler Material as required.	Series 251SC at 6-12 mils	Series 252 SC Mortar at 60-80 mils with 211-215 Mat	252 SC Chembloc (neat) at 12-24 mils.	Series 252 SC at 8-12 mils
SC-26 100% Scale Inhibitor	Akzo Nobel	Series 680 + S1 Powder As required	Series 680 + C1 Powder As required	Series 800 Coroline at 60-80 mils/ Mat Reinforcement	NA	Series 2000 Flakeline at 15-25 Mils
	Carboline	Carboguard 510 or 501 as required	Semstone 110 Primer at 8-10 mils	Semstone 145 at 20-25 mils/Reinforcing Mat	Semstone 145 at 25-30 mils/20/40 Mesh Aggregate Broadcast	Semstone 145 at 15-20 mils
	Sherwin Williams	Steel Seam FT910 (as needed for patch and fill)	Corobond 100 at 4 – 6 mils	Cor Cote HCR Clear at 20 – 25 mils with 1 oz. fiberglass mat	Resufloor 3741 at 8 – 10 mils with 20/40 mesh aggregate broadcast	Resufloor 3741 at 12 – 25 mils
	Tnemec Company	Series 215 or Series 217 or N218 Mortar As required	Series 201 Epoxoprime at 6-10 mils	239SC Chembloc Mortar at 60-80 mils with 211-215 Mat	239 SC Chembloc (neat) at 16-24 mils	Tneme-Glaze Series 282 at 6-12 mils

PART 3 EXECUTION

3.01 COATINGS

A. Workmanship:

1. Do not use coating products until the Engineer or Owner's Representative has accepted the affidavits specified in paragraphs 1.07 and 2.01, and inspected the materials, and the CTR has trained the Contractor in the surface preparation, mixing, and application of each coating system.
2. Erect and maintain protective enclosures as stipulated per SSPC-Guide 6 Guide for Containing Debris Generated During Paint Removal Operations.

B. Shop and Field Coats:

1. Shop Applied Prime Coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Use only Shop-applied primer compatible with the specified coating system and applied at the minimum DFT recommended by the CSM. Provide data sheets identifying the shop primer to the on-site coating application personnel. Perform adhesion tests on the shop primer as specified in paragraph 3.01 B.3. Adhesion Confirmation. Remove damaged, deteriorated, and poorly applied shop coatings that do not meet the requirements of this Section and recoat the surfaces. If the shop primer coat meets the requirements of this Section, the field coating may consist of touching up the shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity.
2. Field Coats: Apply field coats consisting of one or more prime coats and one or more finish coats to build up the coating to the specified DFT. Unless otherwise specified, do not apply finish coats until other work in the area is complete and previous coats have been inspected.
3. Adhesion Confirmation: Perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that (1) the shop applied prime coat adheres to the substrate, and (2) the specified field coatings adhere to the shop coat. Test results showing an adhesion rating of 5A on immersed surfaces and 4A or better on other surfaces are required for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 5B on immersed surfaces and 4B or better on other surfaces are acceptable for coating thicknesses less than 5 mils.
4. The same QC and quality assurance inspection requirements are applicable for shop applications as for field applications.

C. Application Location Requirements:
1. For equipment, Non-immersed: Items of equipment, or parts of equipment that are not immersed in service, and then finish coated in the field after installation with the specified or acceptable color. If the shop primer requires topcoating within a specified period, finish coat the equipment in the shop and then touch-up paint after installation. If equipment removal and reinstallation is required for the project, perform touch-up coating work in the field following installation.
2. Equipment, Immersed: Perform all surface preparation and coating work in the field for all items of equipment parts or fabrications that are immersed when in service, with the exception of manufacturer-finished pumps and valves. Coating systems applied to immersed equipment shall be pinhole free, which can only be verified by holiday/spark testing.

3.02 PREPARATION

A. General:
1. Prepare each type of in accordance with the specific requirements of each coating specification sheet (COATSPEC) and the following. In the event of a conflict, the COATSPEC sheets shall take precedence.
2. Clean and dry surfaces to be coated. Before applying coating or surface treatments remove oil, grease, dirt, rust, loose mill scale, old weathered coatings, and other foreign substances. Remove oil and grease before mechanical cleaning is started. Where mechanical cleaning is accomplished by blast cleaning, wash, grade, and free the abrasive from contaminants that might interfere with the adhesion of the coatings. Use air for blast cleaning that is sufficiently free of oil and moisture so as not to cause detrimental contamination of the surfaces to be coated.

3. QCP to review surfaces to be coated before application of a coating. Correct surface defects identified by the inspector at no additional cost to the Owner.
4. Schedule cleaning and coating so that dust and spray from the cleaning process does not fall on wet, newly coated surfaces. Remove or mask hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces prior to surface preparation and coating operations. Reinstall removed following completion of coating. Disconnect and move equipment adjacent to walls to permit cleaning and coating of equipment and walls. Replace and reconnect items following coating.

B. Blast Cleaning:
   1. Meet the following requirements for abrasive blast cleaning:
      a. Do not reuse used or spent blast abrasive on this project.
      b. Filter compressed air for blast cleaning and ensure it contains no condensed water and no oil. Clean moisture traps at least once every 4 hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment.
      c. Install oil separators just downstream of compressor discharge valves and at the discharge of the blast pot discharges. Check and clean on the same frequency as the moisture traps as defined above.
      d. Regulators, gauges, filters, and separators must be in use on compressor air lines to blasting nozzles at all times during this work.
      e. Install an air dryer or desiccant filter drying unit which dries the compressed air prior to blast pot connections. Use and maintain the dryer for the duration of surface preparation work.
      f. Use abrasive blast nozzles of the venturi or other high velocity type supplied with a minimum of 100 pounds per square in gauge (psig) air pressure and sufficient volume to obtain the blast cleaning production rates and cleanliness/specified.
      g. Provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.
      h. If, between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, reclean the surface by water blasting, reblasting, and abrasive blast cleaning until the specified degree of cleanliness is reclaimed.
      i. Protect mechanical, electrical, and other equipment adjacent to and surrounding the work area.

C. Solvent Cleaning:
   1. Use emulsifying type solvent wash, solvent wipe, or cleaner, including but not limited to those used for surface preparation in accordance with SSPC SP1 Solvent Cleaning which emits no more than 340 g/l VOCs for AIM regions, contains no phosphates, is biodegradable, removes no zinc, and is compatible with the specified primer.
   2. Use clean white cloths and clean fluids in solvent cleaning.

D. Metallic Surfaces:

1. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the Society for Protective Coatings (SSPC) specified for each coating system. See COATSPEC for each coating system in this Section. The profile depth of the surface to be coated shall be in accordance with the COATSPEC requirements in this Section measured by Method C of ASTM D4417. Select blast particle size to produce the specified surface profile. Use the solvent in solvent cleaning operations as recommended by the CSM.
2. Prepare metallic surfaces for degree of cleanliness based upon comparison with SSPC-VIS1-89 (ASTM D2200), and as described in the COATSPEC for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection, on the first day of cleaning operations, provide abrasive blast metal reference panels to the standards specified for acceptance by the Construction Manager. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels accepted by the Construction Manager as meeting the requirements of the specifications shall be initialed by the Contractor and coated with a clear non-yellowing finish. Provide a reference panel for each type of abrasive blasting to be used as the comparison standard throughout the project.
3. Blast cleaning requirements for steel, ductile iron, and stainless steel substrates are as follows:
    a. Prepare external surfaces of steel piping shall in accordance with SSPC SP10 (Near White Metal Blast Cleaning) and prime before installation. Prepare ductile iron piping surfaces including fittings in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Prepare all other steel surfaces to white metal blast cleaning per SSPC SP5.
    b. Abrasive blast stainless steel surfaces in accordance with SSPC SP16 to leave a clean uniform appearance with a minimum uniform surface profile of 1.5 to 2.5 mils.
    c. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products or embedded abrasive from substrate by vacuum cleaning prior to coating application.
    d. Prevent contamination of the surface after blasting from worker's fingerprints, deleterious substances on workers' clothing, or from atmospheric conditions.
    e. Continuously monitor maintain ambient environmental conditions in the enclosure to ensure the degree of cleanliness is held and no "rust back" occurs prior to coating material application.

E. Concrete Surfaces:
1. Inspect concrete surfaces prior to surface preparation and prepare concrete surfaces in accordance with SSPC-SP13 (also called NACE 6).
2. Prior to surface preparation for cleanliness and profile, prepare substrate cracks and areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges, per CSM recommendations.
3. Evaluate the surface profile for prepared concrete surfaces to be coated by comparing the profile of the prepared concrete with the profile of graded abrasive paper, as described in ANSI B74.18 or by comparing the profile with the ICRI 310.2 (surface profile replicas). Prepare surface profile in accordance with the COATSPEC requirements and the CSM's recommendations.
4. Inspect surface cleanliness of prepared concrete substrates after cleaning, preparation, and/or drying, but prior to making repairs or applying a coat in the

coating system. Reinspect repaired concrete surfaces for cleanliness prior to application of the coating system.

5. Prepare concrete substrates using methods such as dry abrasive blast cleaning, high, or ultra high-pressure water blast cleaning in accordance with SSPC SP13 and to meet the following requirements:
   a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances.
   b. Open up air voids or bugholes to expose their complete perimeter by blast cleaning or other methods. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable. Concrete substrate must be dry prior to the application of filler/surface or coating system materials.
   c. Produce a concrete surface with a minimum pH of 9.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
   d. Following inspection of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt, and spent abrasive (if dry blast cleaning is used) leaving a dust free, sound concrete substrate.
   e. Remove debris produced by blast cleaning from the structures to be coated and disposed of legally off site by the Contractor.
6. Should abrasive blast cleaning or high or ultrahigh pressure water jetting not remove degraded concrete, use chipping or other abrading tools shall be used to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Concrete substrates must be dry prior to the application of filler/surfacers or coating system materials.
7. Test moisture content of concrete to be coated in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method at least once for every 500 sq ft of surface area to be coated or more often if required by the CSM. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test.
8. If moisture is detected the CSA in cooperation with the CTR shall perform additional moisture testing vis ASTM F1869 or ASTM F2170 to determine the extent of the moisture vapor transmission. Acceptable limits for the application of barrier coatings for ASTM F1869 is <3 pounds/1,000 sq ft/24 hours. Acceptable limits as per ASTM F2170 is an RH value <70 percent.

F. Masonry Surfaces:
   1. Prepare masonry surfaces such as Concrete Masonry Units (CMU) to remove chalk, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   2. Confirm masonry surfaces are dry prior to coating application. If pressure washing or low-pressure water blast cleaning is used for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or when the minimum ambient temperature is 70 degrees F prior to coating application work.

G. Existing Facilities
   1. Contractor shall demonstrate that the existing coating is compatible with field coating by performing a test over the existing coating to be abraded per the CSM's

recommendations to assure good adhesion. Where unacceptable test results (like lifting, blistering, or cracking) are obtained, the Contractor shall follow manufacturer's written instructions as to the necessity of existing coating removal or the need for a tie coat to provide a satisfactory bond between the existing coating and the specified field coating

3.03 APPLICATION

A. Workmanship:
   1. Apply coats to produce an even film of uniform thickness free from runs, drips, ridges, waves, laps, and brush marks and completely coating corners and crevices.
   2. Use equipment designed for application of the materials specified. Equip compressors with suitable traps and filters to remove water and oils from the air. Perform a paper blotter test when requested by the Construction Manager to determine if the air is sufficiently free of oil and moisture so as not to produce deteriorating effects on the coating system. Limit the amount of oil and moisture in spray air to less than the amount recommended by the CSM. Equip spray equipment with mechanical agitators, pressure gages, and pressure regulators, and spray nozzles of the proper sizes.
   3. Apply each coat evenly and sharply cut to line. Avoid over-spraying or spattering coating on surfaces not to be coated. Protect glass, hardware, floors, roofs, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
   4. Use coating applications method -- conventional or airless spray, brush or roller, or trowel -- as recommended by CSM.
   5. Allow each coat to cure or dry thoroughly, according to CSM's printed instructions, prior to recoating.
   6. Lightly sand glossy undercoats to provide a surface suitable for the proper application and adhesion of subsequent coats. Vary color for each successive coat for coating systems when possible.
   7. Prior to overall coating system application on complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer coat material using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties, Mixing and Thinning:
   1. Coatings shall provide a satisfactory film and smooth even surface. Thoroughly stir, strain, and keep coating materials at a uniform consistency during application. Mix coating materials consisting of 2 or more components in accordance with the CSM's instructions. Where necessary to suit the conditions of the surface, temperature, weather, and method of application, the coating may be thinned as recommended by the CSM immediately prior to use. The volatile organic content (VOC) of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, do not reduce coating materials more than necessary to obtain the proper application characteristics. Use thinner as recommended by the CSM.

C. Atmospheric Conditions:
   1. Apply coatings only to surfaces that are dry, and only under conditions of evaporation rather than condensation. Do not apply coating systems during rainy, misty weather, or to surfaces upon which there is frost or moisture condensation. During damp

weather, when the temperature of the surface to be coated is within 10 degrees F of the dew point, forced dehumidification equipment may be used to maintain a temperature of minimum 40 degrees F and 10 degrees F above the dew point for the surfaces to be coated, the coated surface, and the atmosphere in contact with the surface. Maintain these conditions for a period of at least 8 hours or as recommended by the CSM to assure proper coating cure. Where conditions causing condensation are severe, use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain the required atmospheric and surface temperature requirements for proper coating application and cure.

D. Concrete Substrate Temperatures and Detail Treatment:
   1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, and/or blistering in the coating system. The application of the filler/surfacer or restoration mortar and the coating system will only be allowed during periods of falling temperature. This will require that application of the filler/surfacer and coating system only occur during the cooler evening hours in most cases. Include any cost for working outside of normal hours in the bid.
   2. Repair all bubbles, pinholes, or discontinuities that form in the applied coating system material as recommended by the CSM. Repair pinholes in the filler/surfacer material or in the first coat of the coating material in accordance with the CSM's recommendations prior to application of the next coat of material. Open up and fill completely air voids behind or beneath the pinhole with the specified filler/surfacer material. Abrade the coated area around the pinhole repair and reapply the coating over that area.
   3. Perform application detail work per CSM's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:
   1. Do not handle, work on, or otherwise disturb items that have been coated until the coating is completely dry and hard. Recoat or touch-up shop-coated items after delivery at the site, and upon permanent erection or installation with specified coating when it is necessary to maintain the integrity of the film.

F. Method of Coating Application:
   1. Where 2 or more coats are required, provide sufficient compatible color additive or contrasting color in alternate coats to act as indicator of coverage. Do not use color additives containing lead, or lead compounds, which may be destroyed or affected by hydrogen sulfide or other corrosive gas, and/or chromium.
   2. Mechanical equipment, on which the equipment manufacturer's coating is acceptable, touch-up prime and coat with 2 coats of the specified coating system to match the color scheduled.
   3. Do not apply coating to a surface until it has been prepared as specified. Apply the primer or first coat by brush to ferrous surfaces that are not blast cleaned. Coats for blast cleaned ferrous surfaces and subsequent coats for nonblast cleaned ferrous surfaces may be either brush or spray applied. After the prime coat is dry, mark all pinholes and holidays., repair in accordance with CSM's recommendations, and retest before succeeding coats are applied. Unless otherwise specified, brush, roll, or trowel coats for concrete and masonry.

G. Film Thickness and Continuity:
   1. Confirm WFT following application of each coat.
   2. Do not exceed the surface area covered per gallon of coating for various types of surfaces as recommended by the CSM. The first coat, referred to as the prime coat, on metal surfaces refers to the first full paint coat and not to solvent wash, grease emulsifiers, or other pretreatment applications. Apply coatings to the thickness specified, and in accordance with these specifications.
   3. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may need to be applied to achieve the specified DFT.
   4. For concrete substrates, apply a complete skim coat of the specified filler/surfacer material over the entire substrate prior to application of the coating system such that all open air voids and bugholes in the concrete substrate are completely filled prior to coating application.

H. Special Requirements:
   1. Before erection, apply all but the final finish coat to interior surfaces of steel supports, pipe hangers, piping in contact with hangers, and contact surfaces that are inaccessible after assembly. Apply the final coat after erection. Hand clean or power-tool clean areas damaged during erection and recoat with primer coat prior to the application of subsequent coats. Touch-up surfaces after installation. Confirm surfaces to be coated are clean and dry at the time of application.

I. Electrical and Instrumentation Equipment and Materials:
   1. Electrical and instrumentation equipment and materials shall be shop coated by the equipment manufacturer in compliance with the standard (IEEE, ANSI, NEMA, etc.) referenced in the individual equipment specification. Before final acceptance, the Contractor shall touch up scratches on equipment with identical color coating. Finish shall be smooth, free of runs, and match existing finish. Prior to touching up scratches, Contractor shall fill them with an appropriate filler material approved by the CSM so evidence of prior scratches is not visible in the finish surface. Electrical and instrumentation equipment and materials shall be coated in accordance with Section 09 90 00.

J. General:
   1. Upon completion of coating, remove surplus materials, protective coverings, and accumulated rubbish, and thoroughly clean surfaces and repair overspray or other coating-related damage.

3.04 QUALITY CONTROL DOCUMENTATION .

A. Compile all required QC documentation, test reports, checklists, signoffs as required with appropriate signoffs by the Contractor, CSA, CTR, quality inspectors, etc. and submit to Construction Manager.

3.05 COATING SYSTEM SPECIFICATION SHEETS (COATSPEC)

A. General:
   1. Coating systems for different types of surfaces and general service conditions for which these systems are normally applied are specified on the following COATSPEC

sheets. Coat surfaces in accordance with the COATSPEC to the system thickness specified. Use Coating systems as specified in [Finish Schedule in 09 90 00] (or)[paragraph 3.08]. In case of conflict between the Finish Schedule and the COATSPECS, the requirements of the schedule shall prevail.

2. Table A provides a list of Coating Systems included in the project, the type of coating material, and the general surfaces and service conditions for which each system is used. COATSPECS for HP designated systems are included this paragraph 3.06 and COATSPECS for SC designated systems are included in paragraph 3.07.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
HP-1	Amine Cured Epoxy or Modified Amine Cured Epoxy	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel	Continuous Immersion in Wastewater or Wastewater Sludge
HP-2	Epoxy First Coat with Acrylic Aliphatic Polyurethane Finish Coat (for U.V. Light Resistance)	Carbon Steel, Ductile Iron, Cast Iron	Weathering exposure including U.V. sunlight direct exposure. Apply above splash or spray zone.
HP-3	Modified Amine or Blended Amine Cured Epoxy	Concrete and Concrete Block Masonry	Continuous Immersion in Wastewater or Wastewater Sludge
HP-4	Blended Amine Cure Epoxy Linings	Concrete and Masonry (Non-Brick)	Headspace Exposure to Biogenic Sulfide Corrosion and Related Sulfuric Acid Attack
HP-5	Blended Amine Cured Epoxy	Carbon Steel, Ductile Iron or Cast Iron	Headspace Exposure to Biogenic Sulfide Corrosion and Related Sulfuric Acid Exposure
HP-6	Blended Amine Cured Epoxy Trowel Applied System	Concrete and Concrete Block Masonry	Intermittent Immersion in Wastewater or Wastewater Sludge and Biogenic Sulfide Corrosion – Headspace Exposure and Abrasive Conditions
HP-7	Blended Amine Cured Epoxy	Carbon Steel, Ductile Iron or Cast Iron	Steel Substrate in Mesophilic Anaerobic Digester Service
HP-8	Blended Amine Cured Epoxy System	Concrete	Concrete Substrates in Mesophilic Anaerobic Digesters
HP-9	High Temp Novolac or Acceptable Alternative	Carbon Steel, Ductile Iron or Cast Iron	Steel Substrate in Thermophilic Anaerobic Digester Service
HP-10	High Temp Novolac or Acceptable Alternative	Concrete	Concrete Substrates in Thermophilic Anaerobic Digesters
HP-11	High Build High Strength Semi Structural Blended Amine Cured Epoxy System	Concrete and Concrete Block Masonry	Intermittent Immersion in Wastewater or Wastewater Sludge and Biogenic Sulfide Corrosion – Headspace Exposure and Abrasive Conditions
HP-12	Urethane Cement	Concrete Tank Floors and 4-7-ft Seamlessly onto Tanks Walls	Moisture Vapor Transmission (MVT) Suppression System with Unlimited Potential to block MVT for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.
HP-13	Urethane Cement or Epoxy Based Specialty MVT Primers	Concrete Tank Floors and 4-7-ft onto Tanks Walls	Moisture Vapor Transmission (MVT) Suppression System to block MVT up to 20 lbs./1,000 sq ft/24 hours as per ASTM F1869 for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
HP-14	Epoxy Based Specialty MVT Primers	Concrete Tank Floors and 4-7-ft onto Tanks Walls	Moisture Vapor Transmission (MVT) Suppression System to block MVT up to 10 lbs./1,000 sq ft/24 hours as per ASTM F1869 for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.
SC-1	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 50% Sodium Hydroxide
SC-2	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 18% Sodium Hypochlorite
SC-3	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 12.5% Sodium Hypochlorite
SC-4	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 25% Hydrofluorosilicic Acid
SC-5	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 56% Acetic Acid
SC-6	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 50% Aluminum Chlorohydrate
SC-7	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 30% Aluminum Oxide
SC-8	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 50% Citric Acid
SC-9	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 100% Defoaming Solution
SC-10	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 50% Ferric Chloride
SC-11	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 12% Ferric/Ferrous Sulfate
SC-12	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 25% Hydrogen Peroxide
SC-13	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 34% Hydrogen Peroxide
SC-14	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 50% Hydrogen Peroxide
SC-15	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 100% Methanol
SC-16	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 15% Peracetic Acid
SC-17	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 35% Peracetic Acid

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
SC-18	Novolac Epoxy, Vinyl Ester Novolac, Vinyl Ester	Concrete	Secondary Containment for 75% Phosphoric Acid
SC-19	Amine Cured Epoxy, Modified Amine Cured Epoxy, Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 30% Aluminum Chloride
SC-20	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 35% Sodium Bisulfite
SC-21	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 38% Sodium Bisulfite
SC-22	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 93% Sulfuric Acid
SC-23	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 98% Sulfuric Acid
SC-24	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment for 32% Urea Ammonium Nitrate
SC-25	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment 40% Ammonium Sulfate
SC-26	Novolac Epoxy, Vinyl Ester Novolac Epoxy, Vinyl Ester	Concrete	Secondary Containment 100% Scale Inhibitor

Coating System Specification Sheets (COATSPEC)

Coating System Identification–HP-1

1.	Coating Material:	Amine Cured Epoxy or Modified Amine Cured Epoxy
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel
3.	Service Conditions:	Continuous Immersion in Wastewater or Wastewater Sludge
4.	Surface Preparation:	
a.	Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 3.0 to 4.0 mils. Vacuum clean to remove all dust, dirt, loose material (including all existing coatings if a complete recoating project).
b.	Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 or SSPC SP3 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c.	Galvanized Steel:	DO NOT USE GALVANIZED STEEL in Wastewater or Sludge Immersion Service.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e.	Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
f.	Stainless Steel Fastener Surfaces: when stainless steel fasteners	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these

Coating System Specification Sheets (COATSPEC)

Coating System Identification–HP-1

	are electrically continuous with coated carbon steel	fasteners shall be completely sealed with a polysulfide sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:	
a.	Coating System Thickness:	30-40 DFT.
b.	Coatings:	Primer or First Coats - One coat at CSM's recommended DFT.
c.	Finish Coats:	One or more coats at CSM's recommended DFT per coat to achieve the total system DFT.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Perform Holiday Detection over 100 percent of the coated surface area in accordance with ASTM D5162. Acceptance Criteria shall be no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 24 locations representative of all components making up the internal mechanisms of the clarifiers or sludge thickness or DAFT units, etc. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria: minimum 850 psi with failure plane at substrate for 75 percent of load fixture surface area.
f.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5- to 2.0-mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification–HP-2

1.	Coating Material:	Epoxy First Coat with Acrylic Aliphatic Polyurethane Finish Coat (for U.V. Light Resistance)
2.	Surfaces:	Carbon Steel, Ductile Iron, Cast Iron
3.	Service Conditions:	Weathering exposure including U.V. sunlight direct exposure. Apply above splash or spray zone.
4.	Surface Preparation:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 2.0-2.5 mils. Vacuum clean to remove all dust, dirt, and spent abrasive and other loose material. (Including removal of all existing coatings if it is a complete recoating project.)
a.	Shop Primed Steel:	DO NOT USE SHOP PRIMED COMPONENTS in this service unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 or SSPC SP3 and abrade the peripheral intact coating area the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0- to 1.5 mil profile in the existing primer.

Coating System Specification Sheets (COATSPEC)

Coating System Identification–HP-2

	Vacuum clean to remove all loose dust, dirt, coatings, or other materials.
b. Galvanized Steel:	DO NOT USE GALVANIZED STEEL in these service conditions.
c. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
d. Stainless Steel Surfaces:	Above waterline or splash zone, no surface preparation required. Same for stainless steel fasteners – no surface preparation required.
5. Field Application:	
a. Coating System Thickness:	13-20 mils DFT.
b. Coatings:	Primer or First Coat: 1-2 Coats for 10-15 mils DFT. Finish Coat: 3-5 mils DFT.
c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
d. Post Cure QC Testing:	Perform Holiday Detection over 100 percent of the coated surface area in accordance with ASTM D5162. Acceptance Criteria: no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 12 locations representative of all components making up the weather exposed mechanisms of the clarifiers or sludge thickness or DAFT units. If other structures are to be coated, perform tests at a number of locations recommended by the CSM. Acceptance Criteria: minimum 850 psi with substrate for 75 percent load fixtures surface area.
e. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area un areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5- to 2.0-mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-3

1. Coating Material:	Modified Amine or Blended Amine Cured Epoxy
2. Surfaces:	Concrete and Concrete Block Masonry
3. Service Conditions:	Continuous Immersion in Wastewater or Wastewater Sludge
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard

	details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c. Coatings:	Finish: One or more coats at CSM's recommended DFT per coat to the specified system thickness.
d. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e. Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-3

	of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-4

1. Coating Material:	Blended Amine Cure Epoxy Linings
2. Surfaces:	Concrete and Masonry (Non-Brick)
3. Service Conditions:	Headspace Exposure to Biogenic Sulfide Corrosion and Related Sulfuric Acid Attack
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating

Coating System Identification – HP-4

	terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material) is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application. Surface preparation shall produce a minimum concrete surface pH of 9.0.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c. Coatings:	Primer: Optional for controlling outgassing. Finish: One or more coats at CSM's recommended DFT per coat to the specified system thickness.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-4

d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-5

1.	Coating Material:	Blended Amine Cured Epoxy
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron
3.	Service Conditions:	Headspace Exposure to Biogenic Sulfide Corrosion and Related Sulfuric Acid

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-5

		Exposure
4.	Surface Preparation:	
	a. Carbon Steel:	Abrasive blast clean to White Metal Blast Degree of Cleanliness per SSPC SP5 to achieve a minimum surface profile of 3.0 to 5.0 mils. Vacuum clean to remove all dust, dirt, loose material (including all existing coatings if a complete recoating project).
	b. Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 or SSPC SP3 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0- to 1.5-mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
	c. Galvanized Steel:	DO NOT USE GALVANIZED STEEL IN THIS SERVICE.
	d. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
5.	Field Application:	
	a. Coating System Thickness:	40-60 mils DFT.
	b. Coatings:	Primer or First Coat: One coat at CSM's recommended DFT.
	c. Finish Coats:	One or more coats at CSM's recommended DFT per coat to achieve the total system DFT.
	d. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
	e. Post Cure QC Testing:	Perform Holiday Detection over 100 percent of the coated surface area in accordance with ASTM D5162. Acceptance Criteria: no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 12 locations representative of all components making up the surface area to be coated. Acceptance Criteria: minimum 850 psi with adhesion failure plane at metal substrates at 75 percent of load fixture surface area.
	f. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area un areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5- to 2.0-mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-6

1.	Coating Material:	Blended Amine Cured Epoxy Trowel Applied System
2.	Surfaces:	Concrete and Concrete Block Masonry
3.	Service Conditions:	Intermittent Immersion in Wastewater or Wastewater Sludge and Biogenic Sulfide

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-6

	Corrosion – Headspace Exposure and Abrasive Conditions
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-6

		If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b.	Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c.	Coatings:	Primer: Optional to control outgassing. Finish: One coat at 125 mils Trowel Applied.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-7

1.	Coating Material:	Blended Amine Cured Epoxy
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron
3.	Service Conditions:	Steel Substrate in Mesophilic Anaerobic Digester Service
4.	Surface Preparation:	
a.	Carbon Steel:	Abrasive blast clean to White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 3.0 mils. Vacuum clean to remove all dust, dirt, loose material (including all existing coatings if a complete recoating project).
b.	Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 or SSPC SP3 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0- to 1.5-mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c.	Galvanized Steel:	DO NOT USE GALVANIZED STEEL IN THIS SERVICE.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
5.	Field Application:	
a.	Coating System Thickness:	60-80 mils DFT.
b.	Coatings:	Primer or First Coat: One coat at CSM's recommended DFT.
c.	Finish Coats:	One or more coats at CSM's recommended DFT per coat to achieve the total system DFT.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Perform Holiday Detection over 100 percent of the coated surface area in accordance with ASTM D5162. Acceptance Criteria: no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 12 locations representative of all components making up the surface area to be coated. Acceptance Criteria: minimum 850 psi with adhesion failure plane at metal substrates at 75 percent of load fixture surface area
f.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area un areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5- to 2.0-mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-8

1.	Coating Material:	Blended Amine Cured Epoxy System

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-8

2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates in Mesophilic Anaerobic Digesters
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-8

		Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b.	Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c.	Coatings:	Primer: As required by CSM system application instructions. Reinforcement: As required by CSM system application instructions. If required: Finish: As required by CSM system application instructions.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work). Perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at 1 location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2-inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3-inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-8

	the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-9

1.	Coating Material:	High Temp Novolac or Acceptable Alternative
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron
3.	Service Conditions:	Steel Substrate in Thermophilic Anaerobic Digester Service
4.	Surface Preparation:	
a.	Carbon Steel:	Abrasive blast clean to White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 3.0 mils. Vacuum clean to remove all dust, dirt, loose material (including all existing coatings if a complete recoating project).
b.	Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 or SSPC SP3 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0- to 1.5-mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c.	Galvanized Steel:	DO NOT USE GALVANIZED STEEL IN THIS SERVICE.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
5.	Field Application:	
a.	Coating System Thickness:	60-80 mils DFT.
b.	Coatings:	Primer or First Coat: One coat at CSM's recommended DFT.
c.	Finish Coats:	One or more coats at CSM's recommended DFT per coat to achieve the total system DFT.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Perform Holiday Detection over 100 percent of the coated surface area in accordance with ASTM D5162. Acceptance Criteria: no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 12 locations representative of all components making up the surface area to be coated. Acceptance Criteria: minimum 850 psi with adhesion failure plane at metal substrates at 75 percent of load fixture surface area.
f.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area un areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5- to 2.0-mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-10

1. Coating Material:	High Temp Novolac or Acceptable Alternative
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates in Thermophilic Anaerobic Digesters
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer) material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the

Coating System Identification – HP-10

		prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b.	Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c.	Coatings:	Primer: Optional to control outgassing. Finish: As required by CSM system application instructions.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at -1 location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-10

	the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-11

1. Coating Material:	High Build High Strength Semi Structural Blended Amine Cured Epoxy System
2. Surfaces:	Concrete and Concrete Block Masonry
3. Service Conditions:	Intermittent Immersion in Wastewater or Wastewater Sludge and Biogenic Sulfide Corrosion – Headspace Exposure and Abrasive Conditions
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances.

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	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Coating System Thickness:	100-125 mils dry film in addition to the parge coat.
c. Coatings:	Primer: Optional to control outgassing. Finish: One coat at 125 mils.
d. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e. Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria is average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.

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	• Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-12

1. Coating Material:	Urethane Cement
2. Surfaces:	Concrete Tank Floors and 4-7-ft Seamlessly onto Tanks Walls
3. Service Conditions:	Moisture Vapor Transmission (MVT) Suppression System with Unlimited Potential to block MVT for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of MVT system to fill all bugholes and voids and create a complete parge coat of

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		the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions. The CSA shall engage the CSM and CTR for specific application instruction for the MVT systems for both horizontal and vertical applications.
b.	MVT System Thickness:	System DFT as per CSM System Instructions above parge coat.
c.	Coatings:	Finish: With the appropriate specified topcoat to meet the service requirements.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at 1 location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations.

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	• Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-13

1. Coating Material:	Urethane Cement or Epoxy Based Specialty MVT Primers
2. Surfaces:	Concrete Tank Floors and 4-7-ft onto Tanks Walls
3. Service Conditions:	Moisture Vapor Transmission (MVT) Suppression System to block MVT up to 20 lbs./1,000 sq ft/24 hours as per ASTM F1869 for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces, and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of MVT system to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness.

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	Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions. The CSA shall engage the CSM and CTR for specific application instruction for the MVT systems for both horizontal and vertical applications.
b. MVT System Thickness:	System DFT as per CSM System Instructions above parge coat.
c. Coatings:	With the appropriate specified topcoat to meet the service requirements.
d. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e. Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed on at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – HP-14

1. Coating Material:	Epoxy Based Specialty MVT Primers
2. Surfaces:	Concrete Tank Floors and 4-7-ft onto Tanks Walls
3. Service Conditions:	Moisture Vapor Transmission (MVT) Suppression System to block MVT up to 10 lbs./1,000 sq ft/24 hours as per ASTM F1869 for Wastewater Immersion. MVT systems are to be used in conjunction with the appropriate specified topcoat depending on the system requirements.
4. Surface Preparation:	Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating. All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum-cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
a. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation must open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 6 in accordance with ICRI 310.2R. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces, and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer) material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 4 in accordance with ICRI 310.2R prior to coating application.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of MVT system to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions. The CSA shall engage the CSM and CTR for specific application instruction for the MVT systems for both horizontal and vertical applications.
b. MVT System Thickness:	System DFT as per CSM System Instructions above parge coat.

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Coating System Identification – HP-14		
c.	Coatings:	With the appropriate specified topcoat to meet the service requirements.
d.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
e.	Post Cure QC Testing:	Holiday Detection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583: Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed on at least at one location for every 1,000 sq ft of area to be coated and be performed at areas representative of the entire area to be coated if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
f.	Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 125 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

3.06 SECONDARY CONTAINMENT COATSPECS - SC SYSTEMS SC1 THROUGH SC26

This section contains all the information for surface preparation, field application, coating system thickness, routine QC inspection tasks, Post cure QC testing and Pinhole, Holiday, or Defect Repair

Procedure for all the listed Secondary containment systems in COATSPEC. See each individual system for acceptable surfaces and service conditions.

A. Surface Preparation;
   1. General
      a. Confirm that the exterior of buried concrete structures will be waterproofed in accordance with Section 07 10 00 prior to application of this coating.
      b. Prepare all coating termination and transition details in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. Submit CSM's standard detail drawings for all such coating applications. If standard details are not available for a given detail treatment, provide special details prepared by the CSM at no additional cost to the Owner, the Engineer, or any other party.
      c. If wet abrasive or water jetting surface preparation methods were used, allow the concrete substrate to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application except when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, vacuum clean all surfaces to be coated to remove all loose dirt, dust, or other loose materials. Thorough washdown of prepared concrete by water rinsing may be used in place of vacuum cleaning.
   2. Concrete
      a. Allow new concrete surfaces to cure for at least 28 days and to dry to the moisture content recommended by the CSM. Test moisture content as specified in paragraph 3.02. Except as otherwise specified, remove loose concrete, form oils, surface hardeners, curing compounds, and laitance from surfaces by abrasive blasting and chipping, and repair voids repaired as specified in Section 03 30 00. Perform crack treatment per the CSM's Standard Detail Drawings. Abrade concrete to achieve a uniform minimum concrete surface profile of CSP 6. If the parge coat (filler/surfacer material) is non-polymer modified, brush blast following adequate cure per the CSM's instructions to produce a uniform concrete surface profile of CSP 4 in accordance with ICRI 310.2R prior to coating application. After cleaning, fill air voids or bugholes with a surfacer or block filler. Apply the filler/surfacer material as a complete parge coat of the substrate.
      b. For existing concrete that has been degraded, apply a skim coat of a surfacer or filler material to restore the substrate to a coatable condition. Confirm the filler or surfacer material is compatible with the coating system.
   3. Masonry
      a. Allow new masonry surfaces to age for at least 28 days. Fill and repoint holes or other joint defects with mortar and repointed. Remove loose or splattered mortar by scraping and chipping. Test masonry surfaces for moisture content in accordance with the CSM's recommendations.
      b. Clean masonry surfaces with clear water by washing and scrubbing to remove foreign and deleterious substances.
      c. Do not use muriatic acid shall. After cleaning, fill or seal masonry surfaces with a sealer or block filler compatible with the specified primer.

B. Field Application

1. General
    a. Apply surfacer or filler per CSM's recommendations prior to application of coating.
    b. Allow drying time between filler/surfacer and secondary containment system as specified by the CSM for the site conditions.
    c. If the maximum recoat time is exceeded, prepare surface by solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
    d. Completely fill all bugholes and voids in the substrate, and completely cover the substrate with the parge coat unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness.
2. Coating System Thickness
    a. System DFT as per CSM System Instructions above parge coat.
3. Coatings
    a. Primer: As required by CSM system application instructions.
    b. Reinforcement as required by CSM system application instructions.
    c. Finish: As required by CSM system application instructions.
4. Routine QC Inspection Tasks
    a. Refer to Tables in paragraph 3.09.
5. Post Cure QC Testing
    a. Perform Holiday Detection over 100 percent of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Perform holiday testing after application and adequate cure of the spray applied coating material. Perform holiday detection in accordance with ASTM D4787.
    b. Acceptance Criteria for Holiday Detection is no pinholes or holidays.
    c. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate.
    d. Acceptance Criteria for adhesion testing is minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (Provide MOCK-UP of 200 sq ft for verification purposes prior to commencing with production coating work), perform adhesion testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. Perform coating system adhesion tests at least at one location for every 1,000 sq ft of area to be coated and at areas representative of the entire area to be coated. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75 percent of failure plane on back of load fixture within the concrete substrate.
6. Pinhole, Holiday, or Defect Repair Procedure
    a. Repair pinholes and holidays identified by Holiday Detection as follows:

1) Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate.
2) Chip out and remove the concrete to exposure the full dimensions in all 3 directions of the air void responsible for the defect.
3) Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
4) Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces.
5) Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
6) Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations.

b. Apply the coating system in the number of coats necessary to achieve the specified DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. DFT thickness as per the manufacturer's written instructions. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-1

1.	Coating Material:	Amine Cured/Novolac/Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 50% Percent Sodium Hydroxide Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-2

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 18% Percent Sodium Hypochlorite Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-3

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 12.5% Percent Sodium Hypochlorite Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-4

1.	Coating Material:	Amine Cured/Novolac/Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 25% Percent Hydrofluorosilicic Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-5

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 56% Percent Acetic Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-6

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 50% Percent Aluminum Chlorohydrate Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-7

1.	Coating Material:	Amine Cured/Novolac/Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 30% Percent Aluminum Oxide Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-8

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 50% Percent Citric Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-9

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 100 % Percent Defoaming Solution Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-10

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 50% Percent Ferric Chloride Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-11

1.	Coating Material:	Amine Cured/Novolac/Vinyl Ester Epoxy
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 12% Percent Ferric/Ferrous Sulfate Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-12

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 25% Percent Hydrogen Peroxide Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-13

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 34% Percent Hydrogen Peroxide Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-14

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 50% Percent Hydrogen Peroxide Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-15

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 100% Percent Methanol Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-16

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 15% Percent Peracetic Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-17

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 35% Percent Peracetic Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-18

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 75% Percent Phosphoric Acid Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-19

1.	Coating Material:	Amine Cured/Novolac/Vinyl Ester Epoxy
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 30% Percent Aluminum Chloride Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-20

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 35% Percent Sodium Bisulfite Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-21

1.	Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2.	Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3.	Service Conditions:	Secondary Containment Area for 38% Percent Sodium Bisulfite Handling and Storage
4.	Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-22

1. Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2. Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3. Service Conditions:	Secondary Containment Area for 93% Percent Sulfuric Acid Handling and Storage
4. Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-23

1. Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2. Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3. Service Conditions:	Secondary Containment Area for 98% Percent Sulfuric Acid Handling and Storage
4. Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-24

1. Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2. Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3. Service Conditions:	Secondary Containment Area for 32% Percent Urea Ammonium Nitrate Handling and Storage
4. Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-25

1. Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2. Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3. Service Conditions:	Secondary Containment Area for Secondary Containment 40% Ammonium Sulfate
4. Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

Coating System Specification Sheets (COATSPEC)

Coating System Identification – SC-26

1. Coating Material:	Novolac/ Vinyl Ester Novolac Epoxy/Vinyl Ester
2. Surfaces:	Concrete and Concrete Block Masonry (Non-Brick)
3. Service Conditions:	Secondary Containment Area for Secondary Containment 100% Scale Inhibitor
4. Surface Preparation, Substrate Repair, Coating System Thickness, QC Inspection and Testing and Holiday/Defect Repair	See section 3.07.A for details

3.07 FINISH SCHEDULE

Insert a partial copy of the 09 90 00 finish schedule here and populate. This is only to be used when 09 96 00 is a standalone spec and the project is not relying on the finish schedule from 09 90 00. If using 09 90 00 and its finish schedule, insert the following here:

A: Refer to 09 90 00 for the Finish Schedule.

3.08 ROUTINE QUALITY CONTROL INSPECTION/TESTING REQUIREMENTS

A. The routine QC inspection tasks and tests listed below are required for all standard High Performance Coating Systems covered in this Section. All findings to be compared for compliance with this Section and the referenced product data sheets from the CSM. All of the QC tasks/tests listed below are to be included in the Contractor's QC Testing and Inspection Plan as required in this Section and documented on Form 09 96 00A. The frequency of any test or inspection task may need to be adjusted based upon consistent or inconsistent quality results. Key tests/verifications are required for 100% all surfaces. Measurement/testing should be adjusted as required to confirm 100% of the coating is in compliance with the requirements.

Routine Quality Control Inspection/Testing Requirements Table

Inspection Task or Test	Referenced Standard or Practice	Acceptance Criteria	Frequency of Test or Inspection Task
Inspect compressed air to be free of oil and moisture.	ASTM D4285	Free of Oil and Moisture	Every 2 hours per shift worked.

Routine Quality Control Inspection/Testing Requirements Table

Inspection Task or Test	Referenced Standard or Practice	Acceptance Criteria	Frequency of Test or Inspection Task
Check pressure gauge for water jetting or test pressure for abrasive blast cleaning compressed air.	Needle Gage No Standard	As Specified	Every 4 hours per shift worked.
Measure ambient air and substrate temperature.	Electronic Hygrometer Positector or Elcometer DPM	As per CSM Product data Sheets	Every 2 hours per shift worked.
Measure relative humidity and dew point of air in coating area.	Electronic Hygrometer Positector or Elcometer DPM	Surface Temperature 5°F above the Dew Point and Stabilized	Every 2 hours per shift worked.
Test concrete substrate for moisture.	Phase 1- ASTM D4263 (Qualitative) Phase 2 (If Moisture Present) – ASTM F1869 or ASTM F2170	ASTM F1869-<3lbs per 1000 Sq Ft/24 Hrs ASTM F2170 70% RH or less	Twice per shift worked and prior to coating application.
Test moisture content in concrete block with moisture meter.	Per CSM's Recommendations	<6% Moisture Content	Every 25 sq. f.t to be coated prior to coating application.
Inspect steel or other ferrous Metals for Degree of Cleanliness in Carbon Steels.	SSPC VIS-1 (ASTM D2200) SSPC VIS-3 SSPC VIS-4 SSPC VIS-5	As per the Specification	All surfaces checked prior to coating – 100% surface in compliance as per SSPC SP standards.
Cast and Ductile Iron Degree of Cleanliness.	NAPF 500-03 NAPF 500-03-04 NAPF 500-03-05	As per the Specification	All surfaces checked prior to coating – 100% surface in compliance as per NAPF standards.
Inspect steel or other ferrous metals for degree of dust left on the surface.	ISO 8502-3	Dust Rating 1 Dust Particle Size 0	100% of all surfaces checked prior to coating.
Metal Surface Profile of Steel – Abrasive Blast cleaned.	ASTM D4417 Method A or C (Same for ductile and cast iron and stainless steel)	As per the Specification	100% surface in compliance with manufacturers surface profile requirements
Inspect Concrete Surface Profile by Comparison to Replicas.	ICRI 310.2R	As per the Specification	100% surface in compliance with manufacturers surface profile requirements
Inspect Concrete for Soundness with Hammer Testing	N/A	No Hollow Concrete Areas	Check for soundness visually 100% and hammer test every 10 sq ft or where cracked or loose concrete is apparent visually.
Inspect Surface pH of Prepared Concrete.	ASTM D4262	Min 9 pH	Every 100 sq. ft to be coated.
Calculate Coverage of Filler/Surfacers or Mortars based on CSM's Coverage Robes and Measure Thickness with Needle or Calibrated Wire.	N/A	As per Specification	For all surfaces to be surfaced and filled with parge coat of mortar.
Measure WFT of Coatings Over Metal.	ASTM D4414	As per CSM Product Data Sheets	Every 10 sq ft to be coated.

Routine Quality Control Inspection/Testing Requirements Table

Inspection Task or Test	Referenced Standard or Practice	Acceptance Criteria	Frequency of Test or Inspection Task
Measure WFT of Coatings Over Parge Coats – Troweled Over Concrete or Masonry.	ASTM D4414	As per CSM Product Data Sheets	Every 10 sq ft to be coated.
Visually Inspect All Coating Film for Film Quality e.g. Pinholes, Holidays, Runs, Sags, etc.	N/A	Pinhole Free surface and free of runs and sags	100% of all surfaces to be coated.
Measure DFT of Coatings on Ferrous Metals.	SSPC PA2 Level 3	As Specified	As prescribed by SSPC PA2
Measure DFT of Coatings on Concrete Substrates.	SSPC PA9 Level 3	As Specified	As prescribed by SSPC PA9
Discontinuity Testing (Holiday Detection) on Metal Surfaces.	ASTM D5162 >- 20 mils Method B < - 20mils Method A	Pinhole Free Surface	Addressed in Applicable COATSPECS
Discontinuity Testing (Holiday Detection) on Concrete Substrates.	ASTM D4787	Pinhole Free Surface	Addressed in Applicable COATSPECS
Adhesion Testing on Metallic Substrates.	ASTM D4541	800 psi Min	Addressed in Applicable COATSPECS
Adhesion Testing on Concrete Substrates.	ASTM C4583 ASTM D7234	250 Psi Min	Addressed in Applicable COATSPECS
Reinspect for Rework from all Non-Compliant Issues Identified from QC Inspection listed above.	N/A	Meets all Specified standards	As needed.

3.09 OPTIONAL OWNER QUALITY ASSURANCE REVIEW

A. General:
   1. Inspection by the Owner or others does not limit the Contractor's or CSA's responsibilities for quality workmanship or sole responsibility for QC as specified by this Section or as required by the CSM's instructions. Inspection by the Owner is optional and is additional to any inspection required to be performed by the Contractor.
   2. The Owner may perform, or contract with an inspection agency to perform, QA inspection and testing of the coating work covered by this Section. These inspections may include the following:
      a. Inspect materials upon receipt to ensure that all are supplied by the same CSM.
      b. Inspect to verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
      c. Inspect and record findings for the degree of cleanliness of substrates.
      d. Inspect and record the pH of concrete and metal substrates.
      e. Inspect and record substrate profile (anchor pattern).
      f. Measure and record ambient air and substrate temperature.
      g. Measure and record relative humidity.
      h. Check for the presence of substrate moisture in the concrete.

i. Inspect to verify that correct mixing of coating system materials is performed in accordance with CSM's instructions.

j. Inspect, confirm, and record that the "pot life" of coating system materials is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.

k. Perform adhesion testing.

l. Measure and record the thickness of the coating system.

m. Inspect to verify proper curing of the coating system in accordance with the CSM's instructions.

n. Limited visual observations for defects.

3.10 FINAL INSPECTION

A. General

1. Conduct a final inspection to determine whether coating system work meets the requirements of the specifications.
2. The Construction Manager or Owner's Representative will subsequently conduct a final observation with the Contractor to observe the completed work.
3. Mark all obvious defects or non-conforming work. Reclean and repair as specified at no additional cost to the Owner.

3.11 COATING SYSTEM QUALITY CONTROL CHECKLIST

09 96 00-A COATING SYSTEM QUALITY CONTROL CHECKLIST

Project Name

Owner		**Coating System Manufacturer Technical CTR**	
General Contractor (GC)		**Coating System Applicator (CSA)**	
Area or Structure		**Location within Structure**	
Coating System (e.g., E-1)		**Coating Type (e.g., Epoxy, etc.)**	

Coating System Quality Control Checklist

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
1	Completion of pre-cleaning and substrate decontamination prior to abrasive blast cleaning. (Concrete)	Surface free of all oil, grease, form release agents and all other foreign contaminants	GC QC			
		Host Substrate Min pH of 9 per ASTM D4262	CTR QC			
		ASTM F22- No Moisture Lens Formation	CSA QC			
2	Completion of pre-cleaning and substrate decontamination prior to abrasive blast cleaning (steel/metal)	Surface free of all oil, grease and all other foreign contaminants.	GC QC			
			CTR QC			
			CSA QC			
3	Moisture Testing of Concrete	Step 1- Initial Testing as Per ASTM D4263- if moisture present move to step 2	GC QC			
		Step 2- ASTM F1869- < 3lbs/1000 sq. ft/24 hours If moisture present move to step 2 or 3	CTR QC			
		Step 2 Alternate- ASTM F2170- Substrate RH 70% or less. If moisture present move to step 2 or 3	CSA QC			
4	Soluble Salt Testing (Steel/Metal)	Max 30 micro siemens as per ISO 8502-6/8502-9	GC QC			
			CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
			CSA QC			
5	Ensuring compressed air for abrasive blasting or coating/lining application is free of oil and moisture	ASTM D4285- Free of all oil & moisture	GC QC			
		1 blotter test per 2 hours of compressed air usage	CTR QC			
			CSA QC			
6	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	Conforms to SSPC Guide 6 Guidelines and specification requirements.	GC QC			
			CTR QC			
			CSA QC			
7	Completion of ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	Substrate min of 5 degrees above the dew point and stabilized.	GC QC			
		Recording ambient conditions, a minimum of 4 times per shift/day at 2-hour intervals	CTR QC			
		Negative pressure of enclosure. Visual inspection of enclosure tarps indicating negative pressure.	CSA QC			
8	Completion of Surface Preparation for concrete deep repair applications. (If required)	SSPC SP CAB 1 and SSPC-SP13/NACE #6	GC QC			
		Surface Profile- ICRI CSP#5 minimum	CTR QC			
			CSA QC			
9	Completion of Concrete Deep Repairs (If required) and Related Surface Preparation Rework Prior to Concrete Filler/Re-surfacer/Parge.	SSD Maintained throughout application	GC QC			
		SSPC SP CAB 1 and SSPC-SP13/NACE #6	CTR QC			
		Surface Profile- ICRI CSP#5 minimum	CSA QC			
10	Adhesion testing of host concrete as per ASTM C1583. Conduct tests in three (3) representative locations. Three (3) tests per location. Glue failures are not considered a completed test.	Report all adhesion values measured	GC QC			
		Report average results of test areas.	CTR QC			
			CSA QC			
11	Completion of Concrete Filler/ Re-surfacer/Parge Coat Application to Concrete Prior to Coating System	SSD Maintained throughout application	GC QC			
		Visual inspection of uniformity	CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	Application.	of fill and dispersal	CSA QC			
12	Concrete - Completion of Surface Preparation for coating & lining applications.	SSPC SP CAB 1 and SSPC-SP13/NACE #6	GC QC			
		Surface Profile- ICRI CSP#4 minimum	CTR QC			
			CSA QC			
13	Concrete- Adhesion testing on installed repair mortar (after min 72-hour cure) as per ASTM C1583. Conduct tests in 3 representative locations. 3 tests per location. Glue failures are not considered a completed test.	Minimum 250 psi	GC QC			
		75% minimum host concrete failure	CTR QC			
			CSA QC			
14	Steel - Completion of Surface Preparation for coating & lining applications.	SSPC-SP10/NACE#2 (CS)	GC QC			
		NAPF 500-03 (04&05)	CTR QC			
		ASTM D4417 Method C-Surface Profile ?_mils	CSA QC			
15	Steel- Dust Level Testing- After surface preparation and prior to application of primers/coatings	ISO 8502-3 (Part 3)	GC QC			
		Dust Rating-1	CTR QC			
		Dust Particle Size - 0	CSA QC			
16	Concrete- Completion of Primer Application. (If required)	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
17	Steel- Completion of primer/1st coat application (only required if using a primer or for multicoat coat applications)	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
18	Concrete- Completion of Intermediate Coat Application and of Detail Treatment at Transitions or Terminations. (Only applicable in 2 coat applications)	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
19	Steel- Completion of Intermediate Coat Application and of Detail Treatment at Transitions or	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of	CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	Terminations. (Only applicable in 2 coat applications)	coating defects, pinholes and debris.	CSA QC			
20	Concrete - Completion of Finish Coat Application and of Detail Treatment at Transitions and Terminations.	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
21	Steel- Completion of Finish Coat Application and of Detail Treatment at Transitions or Terminations.	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
22	Completion of Full and Proper Cure of Lining System.	ASTM D5402- No material transfer	GC QC			
		ASTM D2240- Shore D- Must match value stated on CTR PDS data.	CTR QC			
			CSA QC			
23	Concrete - Completion of Testing of Cured Lining System including Adhesion, Holiday (Continuity) Testing.	ASTM D4787- Pinhole/holiday free	GC QC			
		ASTM D7234- TBD by results of ASTM C1583 testing of host concrete and repair mortar	CTR QC			
			CSA QC			
24	Steel - Completion of Testing of Cured coating System including Adhesion, Holiday (Continuity) Testing.	ASTM D5162- Pinhole/holiday free	GC QC			
		ASTM D4541- min 800 psi	CTR QC			
			CSA QC			
25	Concrete- Completion of Localized Repairs to Lining System Following Testing.	ASTM D4787- Pinhole/holiday free	GC QC			
		Visual inspection for film quality- no runs, sags or other defects	CTR QC			
			CSA QC			
26	Steel- Completion of Localized Repairs to Coating System Following Testing.	ASTM D5162- Pinhole/holiday free	GC QC			
		Visual inspection for film quality- no runs, sags or other defects	CTR QC			
			CSA QC			
27	Final Acceptance of Coating/Lining System Installation Including Final	Coatings/linings meet all specification requirements	GC QC			
			CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	Clean-Up Complying with Specification Requirements and the CTR's Quality Requirements.		CSA QC			

END OF SECTION

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SECTION 09 97 00

POTABLE WATER PROTECTIVE COATINGS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This Section specifies coating system materials, surface preparation, and application of ANSI/NSF/CAN 61-600 coating systems to both interior concrete and steel substrates of equipment, tanks, and other components required by regulation to be treated with NSF 61 compliant coatings, and steel tank exteriors to be coated in compliance with AWWA D102, including , but not limited to:
    a. All materials that may come in contact with drinking water, including pipes, gaskets, lubricants and O-Rings, shall be ANSI-certified as meeting the requirements of ANSI/NSF Standard 61, Drinking Water System Components - Health Effects. To permit field-verification of this certification, all components shall be appropriately stamped with the NSF logo. Per Utah Administrative Code R309-550-6
2. This Section Includes coating systems to finish all water tank components, unless otherwise indicated. Without restricting volume or generality, work to be performed under this section may include, but is not limited to:
    a. Interior steel wet areas (Immersion, Roof Structures) and dry areas (Dry Risers and other areas not in immersion or condensation zones).
    b. Exterior steel.
    c. Piping, hangers, and supports.
    d. Repairing surface defects in the tank that may affect performance of the installed Interior Lining (as per NACE SP0178) and Exterior Protective Coating. This will include pitted steel, sharp edges, and any other surface defect that may affect the performance of the linings or coatings.
    e. Overcoating system option for both concrete and steel tanks.
    f. Lining system terminations, necessary environmental controls and the legal collection, temporary storage, removal, and disposal of all debris.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 11 80 Environmental Conditions
2. Section 01 33 00 Submittal Procedures
3. Section 01 45 00 Contractor Quality Control
4. Section 01 45 23 Testing and Inspection Services
5. Section 01 61 45 Area Exposure Designations
6. Section 01 66 00 Product Storage and Handling
7. Section 01 99 00 Reference Forms
8. Section 07 10 00 Dampproofing and Waterproofing
9. Section 09 90 00 General Coating Specifications

10. Section 09 96 00 High Performance Protective Coatings

1.03 DEFINITIONS

A. Specific coating terminology used in this Section is in accordance with definitions contained in ASTM D16, ASTM D3960, and the following definitions.
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. AMPP: Association for Materials Protection and Performance (Merger of National Association of Corrosion Engineers (NACE) and The Society for Protective Coatings (SSPC).
   4. Anchor Pattern: Profile or texture of prepared surface(s).
   5. ANSI: American National Standards Institute.
   6. Bugholes: Small cavities, usually not exceeding 15 millimeters in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.
   7. Coating/Paint/Lining Thickness: The total thickness of primer, intermediate and/or finish coats.
   8. Coating System Applicator (CSA): A generic reference to the specialty coating/lining applicator retained by the General Contractor to install the coating systems specified in this Section. All requirements listed for the CSA ultimately fall under the General Contractor's quality control responsibility to confirm the CSA is meeting all specification requirements.
   9. Coating System Manufacturer (CSM): Refers to the acceptable coating system manufacturer, abbreviated as the CSM.
   10. Coating System Manufacturer's Technical Representative(s) (CTR): Refers to the technical representative(s) of the acceptable CSM and is abbreviated as CTR.
   11. Continuous film or continuity of film: refers to coating layer/system without holidays, pinholes, or other discontinuities.
   12. CQC: Coating System Applicator (CSA) Quality Control Inspector.
   13. Dehumidification: The removal of moisture, humidity, or dampness from the air.
   14. Dew point: Temperature of a given air/water vapor mixture at which condensation starts.
   15. Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001 inch).
   16. Drying/Cure Time: Time interval between application and curing of material before exposure to service conditions.
   17. Dry to Recoat: Time interval between application of material and ability to receive next coat.
   18. Dry to Touch: Time interval between application of material and ability to touch lightly without damage.
   19. Feather Edging: Reducing the thickness of the edge of paint.
   20. Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.
   21. Field Coat: The application or the completion of application of the coating system after installation of the surface at the site of the work.

22. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
23. Holiday: A discontinuity, skip, or void in coating or coating system film that exposes the substrate.
24. Honeycomb: Segregated condition of hardened concrete due to non-consolidation.
25. ICRI: International Concrete Repair Institute.
26. Incompatibility: Inability of a coating to perform well over another coating because of bleeding, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.
27. Laitance: A layer of weak, non-durable concrete containing cement fines that is brought to the surface through bleed water because of concrete finishing and/or over-finishing.
28. Mil: 0.001 inch.
29. NACE: National Association of Corrosion Engineers.
30. NSF International: National Sanitation Foundation.
31. Overspray: Dry spray, particularly such paint that failed to strike the intended surface.
32. Owner's Quality Assurance Representative: Person or persons designated by the Owner to perform Quality Assurance (QA) review of the CSA's Quality Control (QC) reports and inspection and testing work.
33. Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.
34. Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.
35. QA: Quality Assurance.
36. QC: Quality Control.
37. QCTIP: Quality Control Testing and Inspection Plan.
38. QP P3: AMPP-accredited program that evaluates the practices of shop painting facilities.
39. QP1: AMPP-accredited program that evaluates the practices of field painting.
40. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-base material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
41. Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.
42. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.
43. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
44. SSPC: The Society for Protective Coatings.
45. Stripe Coat: A separate coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges by brush. This coat shall not be applied until any previous coat(s) have cured and once applied, shall be allowed to cure prior to the application of the subsequent coat(s).
46. Surface Saturated Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

47. Tie Coat: An intermediate coat used to bond different types of paint coats. Coatings used to improve the adhesion of a succeeding coat.
48. Touch-Up Coating: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
49. TPC: Technical Practice Committee.
50. Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).
51. Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in water or wastewater at least intermittently if not constantly.
52. Weld Splatter: Beads of metal scattered near seam during welding.
53. Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application. Wet film thickness is measured in mils or thousandths of an inch (0.001 inch) and is abbreviated WFT.

1.04 REFERENCES

A. This section contains references to the following documents listed and described below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed and described documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	
ANSI/ASC 29.4 Exhaust Systems	Abrasive Blasting Operations – Ventilation and Safe Practice
ANSI B74.18	Grading of Certain Abrasive Grain on Coated Abrasive Material
ANSI/NSF 61/600	Drinking Water System Components Health Effect
ASTM C1583	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)
ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
ASTM D2200 (SSPC-VIS1)	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

Reference	
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings on Metal Substrates Using Portable Adhesion Testers
ASTM D4787	Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates
ASTM D5162	Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
ASTM 5402	Standard Practice for assessing the solvent resistance of organic coatings using solvent rubs
ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers.
ASTM E337	Standard Test Method for Measuring Humidity with a Psychrometer
AWWA D100-21	Standard for Welded Steel Tanks for Water Storage
AWWA D102-21	Standard for Painting Steel Water-Storage Tanks
AWWA C652-19	Disinfection of Water-Storage Facilities
ASTM F22	Standard Test Method for Hydrophobic Surface Films by the Water-Break Test
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2170	Standard Test Method for Measuring Relative Humidity in Concrete Floor Slabs Using Insitu Probes
FS 595b	Federal Standard Colors
ICRI 310.2	Guideline for Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair
ISO 8502-3 (Part 3)	Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method)
NACE Publication 6D-163	A Manual for Painter Safety
NACE Publication 6F-163	Surface Preparation of Steel or Concrete Tank/Interiors
NACE Publication 6G-164 A	Surface Preparation Abrasives for Industrial Maintenance Painting
NACE Standard SP0178	Design, Fabrication and Surface Finishing Practices for Tanks & Vessels to be Lined for Immersion
NACE Standard SP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE Standard RP0288	Standard Recommended Practice, Inspection of Linings on Steel and Concrete
NACE Standard RP0892	Standard Recommended Practice, Linings Over Concrete in Immersion Service
NACE Publication TPC2	Coatings and Linings for Immersion Service
NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
NAPF 500-03-04	Abrasive Blast Cleaning for Ductile Iron Pipe
NAPF 500-03-05	Abrasive Blast Cleaning for Cast Ductile Iron Fittings
NSF Standard 61/600	ANSI/NSF/CAN Standard 600 "Drinking Water System Components-Health Effects"
OSHA 1910.144	Safety Color Code for Marking Physical Hazards

Reference	
OSHA 1915.35	Standards – 29CFR – Painting
SSPC	Paint Application Specification No. 1.
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-AB 2	Specification for Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 3	Newly Manufactured or Re-Manufactured Steel Abrasives
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC-PA Guide 3	A Guide to Safety in Paint Application
SSPC-PA Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
SSPC PA-Guide 10	Guide to Safety and Health Requirements for Industrial Painting Projects
SSPC-PA Guide 11	Guide for Stripe Coating
SSPC-PA Guide 12	Guide for Illumination of Industrial Painting Project
SSPC SP1	Solvent Cleaning
SSPC SP2	Hand Tool Cleaning
SSPC SP3	Power Tool Cleaning
SSPC SP5/NACE #1	White Metal Blast Cleaning
SSPC SP6/NACE #3	Commercial Blast Cleaning
SSPC SP7/NACE #4	Brush-Off Blast Cleaning
SSPC SP10/NACE #2	Near-White Blast Cleaning
SSPC SP11	Power Tool Cleaning to Bare Metal
SSPC SP WJ-1/NACE WJ-1	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Clean to Bare Substrate
SSPC SP WJ-2/NACE WJ-2	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Very Thorough Cleaning
SSPC SP WJ-3/NACE WJ-3	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Thorough Cleaning
SSPC SP WJ-4/NACE WJ-4	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Light Cleaning
SSPC SP13/NACE #6	Surface Preparation of Concrete
SSPC SP14/NACE#8	Industrial Blast Cleaning
SSPC SP15	Commercial Power Tool Cleaning
SSPC SP16	Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
SSPC SP-CAB 1	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Thorough Cleaning
SSPC SP-CAB 2	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Intermediate Cleaning
SSPC SP-CAB 3	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Brush Blast Cleaning
AMPP SP21548	Pressurized Water Cleaning of Concrete and Cementitious Materials- Thorough Cleaning
SSPC-TR2	Wet Abrasive Blast Cleaning

Reference	
SSPC-TU-3	Overcoating
SSPC-TU-4	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC V2	Systems and Specifications: Steel Structures Painting Manual, Volume 2
SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
SSPC-VIS 4	Visual Standards (Water jetting)
SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)

1.05 QUALITY ASSURANCE

A. General Requirements:
   1. Provide materials and supplies that are standard products of CSMs. Provide materials in each coating system from a single CSM.
   2. The standard products of CSMs other than those specified may be acceptable when it is demonstrated to the Construction Manager that they are equal in composition, durability, usefulness, and convenience for the purpose intended. Requests for consideration of CSMs other than those specified in this Section will be considered in accordance with the requirements of the General Conditions and provided the following minimum conditions are met. Such requests are not a substitution for submittals after the alternative CSMs have been considered and accepted.
      a. The proposed coating system uses an equal or greater number of separate coats to achieve the required total dry film thickness.
      b. The proposed coating system uses coatings of the same generic type as that specified including curing agent type.
      c. Include information listed in paragraph 1.05, demonstrating that the proposed CSM's product is equal to the specified coating system.
      d. Provide a list of Contractor and CSM references for the proposed product where the coating of the same generic type has been applied. Include the project name, city, state, owner, phone number of owner; coating system reference and number from this Section 09 97 00; type of facility in which it was used, generic type, and year coating was applied.
      e. At any time when there is conflict between the CSM's product data and the COAT SPEC requirements regarding surface preparation, material application or any other coating details, the data that provides the more stringent requirements will take precedent.

B. Shop and Field Quality Control Requirements:
   1. The Contractor is solely responsible for the workmanship and quality of the coating system installation by the Contractor's CSA. Inspections by the Owner, Engineer, a Construction Manager, the CTR, or any other party will not relieve or limit the Contractor's responsibilities for the quality of the coating system.
   2. Conform to requirements of this specification and the standards referenced in this Section. Changes in the coating system installation requirements will be allowed only with the written acceptance of the Engineer and CSM before work commences.

3. Only personnel who are trained by the CTR specifically for this contract or who are approved by the CSM specifically for this contract will be allowed to perform the coating system installation specified in this Section.
4. Provide full time inspection with trained and certified quality control (QC) inspectors performing all QC procedures as the coating work proceeds in accordance with the requirements of this section. Minimum qualifications for QC inspectors on concrete projects is AMPP-CCI Level 1 with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified CCI Level 2 Concrete Coatings Inspector. On non-concrete related project the minimum QC inspector is AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience. An AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience may be acceptable providing the AMPP Basic, AMPP Certified and AMPP Senior coating inspectors can each can show verifiable proof of performing inspection successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.
5. Perform all shop surface preparation and coating applications by an AMPP QP3 Certified blast and painting shop in good standing.
6. Perform all field surface preparation and coating applications by a AMPP QP8 ~~1~~ Certified field painting Contractor in good standing for all concrete applications, and AMPP QP-1 for all applications on surfaces other than concrete. Should the contractor working on concrete substrates not have an AMPP QP-8 certification, the QP-1 contractor certification may be acceptable providing the QP-1 contractor can show verifiable proof of performing work successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.
7. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
8. For repairs, provide the same products, or products recommended by the CSM, as used for the original coating.
9. Identify the points of access for inspection by the Owner, the Engineer, or the Owner's Representative. Provide ventilation, ingress and egress, and other safe means necessary for the Owner's or Engineer's personnel or designated representative to safely access the work areas.
10. Conduct the work so that the coating system is installed as specified and inspect the work continually to ensure that the coating system is installed as specified. Correct coating system work that does not conform to the specifications or is otherwise not acceptable to the as-specified requirements at no additional cost to the Owner.
11. Contractor/CSA to submit for approval a Quality Control Testing and Inspection Plan (QCTIP) for the work covered by this Section (see 09 97 00 Quality Control Check List). Include a list all tests and inspection tasks including referenced and applicable standards to be conducted and the frequency in which these tests or tasks will be performed. This frequency can be addressed for certain tests, such as air and substrate temperature or Dew Point, on an hourly per shift basis. Or this frequency can be addressed on a per number of square feet (sq ft) basis for tests and tasks such as wet and dry film thickness tests or adhesion tests. Include in the QCTIP a

written record which identified when (time and date) work not conforming to the specification requirements is identified, a written record of the proposed corrective actions for such non-conforming work and a record of when that action was performed (time and date). Describe all corrective action for non-conforming work described in detail with referenced digital photographs taken of the re-work for subsequent review by the Owner's representative.

12. Submit a daily Quality Control inspection report from the QCP that describes and documents all Quality Control tests and inspection tasks performed including frequency of performance and test results (including test data) and referenced standard followed for each shift the CSA works. Submit these reports on the morning of the following day the work was performed to the Engineer or Owner's Quality Assurance representative for review. Include with the daily QC report a written account of all non-conforming work with annotated digital photographs and subsequent corrective measures. Submit a standard inspection form to be used for these reports for review by the Engineer. The CSA's QC inspector to use the approved inspection report forms to record all quality control inspection and testing throughout the performance of the coating work.
13. Complete the Coating System Quality Control Checklist, Form 09 97 00-A for coating system installations. Follow the sequential steps required for proper coating system installation as specified and as listed in the Coating System Quality Control Checklist. For each portion of the work, install the coating system, document all QC measures and complete sign-offs, as specified, prior to proceeding with the next step. After completing each step as indicated on the Coating System Quality Control Checklist, sign the checklist indicating that the work has been installed and inspected as specified. All signoffs on final checklist must be supported by daily reports indicating the appropriate inspections, documentation (daily), and corrective actions where performed on specific components/pieces.

C. Quality Control Hold Points:
   1. The QCP shall conduct QC inspections at Hold Points during the coating system installation and record the results on Form 09700-A. Coordinate Hold Points with the CTR, Engineer and Construction Manager so they may observe the Quality Control inspections on a scheduled basis. Provide the CTR, Engineer and Construction Manager a minimum of 2 days of notice prior to each Hold Point Inspections. Representative portions of the overall coating work on the project shall be observed by the CTR. The minimum quality control Hold Points shall be as follows:
      a. Environment and Site Conditions. Prior to commencing an activity associated with coating system installation, measure, record, and confirm acceptability of ambient air temperature and humidity as well as other conditions such as proper protective measures for surfaces not to be coated and safety requirements for personnel. The acceptability of the weather and/or environmental conditions within the structure to be determined by the requirements specified by the CSM of the coating system being used.
      b. Conditions Prior to Surface Preparation. Prior to commencing surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts have been eliminated from the surface.
      c. Monitoring of Surface Preparation. Spot check of degree of cleanliness, surface profile, and surface pH testing, as required. Check the compressed air used for surface preparation, vacuum or blow--down cleaning to confirm it is free from oil and moisture.

d. Post Surface Preparation–Upon completion of the surface preparation, measure and inspect for proper degree of cleanliness and surface profile as specified in this Section and in the CSM's written instructions (Product Data Sheets).

e. After surface preparation and prior to the application of primer and coatings the surfaces the CSA must ensure that the acceptable level of remaining dust meets the specification requirements.

f. Steel Pit Fillers & Concrete Repair Mortars; Inspect all pit filling and concrete repair processes to ensure compliance with the specification.

g. Monitoring of Coatings Application–Inspect, measure, and record the wet film thickness and general film quality (visual inspection) for lack of runs, sags, pinholes, holidays, etc. as the application work proceeds.

h. Exterior Post Application Inspection–Identify defects in application work including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness and other problems as may be observed.

i. Dry Film Thickness Measurements- Measure DFT after each coat and record in the daily QC inspection reports. DFT readings for steel surface to be per SSPC-PA2 using Type II Magnetic DFT Gauges for ferrous surfaces and Type II Eddy Current Gauges for non-ferrous surfaces. DFT readings for concrete surface to be taken as per SSPC-PA9 using Ultra Sonic DFT Gauges or by proving materials usage versus square foot coverage. All gauges to be calibrated by the manufacturer or approved agent within 1 year of use. Following SSPC-PA2 and SSPC-PA9 minimum measurement standards may not provide the Quality Control personnel adequate measurement intervals to ensure full compliance to the specification. QC personnel are required to take as many measurements necessary to ensure full compliance to this specification.

j. Interior Post Cure Evaluation – Measure and inspect the overall dry film thickness. Conduct a DFT survey, and perform adhesion testing, holiday detection (spark testing), or cure testing as required based on the type of project and the specific requirements in this Section and/or in the CSM's written instructions. 100 percent of all immersed coatings shall be holiday detection tested, marked and appropriately repaired (partial testing is not an acceptable substitution).

k. Follow-up to Corrective Actions and Final Inspection. Measure and reinspect corrective coating work performed to repair defects identified at prior Hold Points. Include final visual inspection along with follow-up tests such as holiday detection, adhesion tests, and DFT surveys.

D. Optional Owner Quality Assurance Inspection:

1. The Owner and Engineer reserve the right to retain the services of a Quality Assurance Inspection firm to perform random audits of the CSA's Quality Control processes and documentation at any time during the project's progress. Any inspections by the Owner, Engineer, or other owner-related representatives do not relieve the Contractor from retaining sole responsibility for the quality of the installed coating system.

2. Quality Assurance Hold Point Inspections may include, but are not limited to the following processes:

   a. Conditions Prior to Surface Preparation

   b. Environment and Site Conditions

   c. Post Surface Preparation

d. Post Primer Application (If Applicable)
e. Post Intermediate Coat Application (If Applicable)
f. Post Final Coat Application
g. Final Cure & Testing (Including Holiday Detection)
h. Follow-up to Corrective Actions and Final Inspection

3. Coordinate Hold Points with the Owner's Quality Assurance representative so they may observe the CSA's Quality Control inspections on a scheduled basis. Provide the Owner's Quality Assurance representative a minimum of 48 hours of notice prior to conducting Hold Point Inspections.

E. Responsibilities of the CTR:
1. General:
a. Retain or obtain the services of the CTR to be on site to perform the Contractor and/or CSA application training and to routinely inspect and verify in writing that the application personnel have successfully performed representative portions of the surface preparation work, filler/surface application, coating system application, and Quality Control Inspection in accordance with this Section. Include testing or witnessing the contractors testing for the required degree of cleanliness, surface pH for concrete substrates, surface profile of substrates, proper mixing of coating materials, application (including checking the wet and dry film thickness of the coating systems), proper cure of the coating systems, and proper treatment of coating systems at terminations, transitions, and joints and cracks in substrates. Refer to paragraph 1.05 F for Coating System Installation Training for further details on these CTR requirements. These Quality Control verifications are not expected to be full-time, but rather to assure that verifications by the CTR are performed on representative portions of all major steps of the coating work to ensure the CSM approves those representative portions of the work to be in compliance with the CSM's recommendations and instructions. This inspection is in addition to the inspection performed by the Contractor in accordance with paragraph 1.05C of this section. The CTR shall provide an adequate level of oversight of the contractor's quality control processes, at their discretion, to provide sign off that the CSM's products have been properly installed and to fulfill all project warranty requirements.

2. Coating System Installation Training:
a. Provide a minimum of 8 hours of classroom and off-site training for application and supervisory personnel of the CSA. Provide training to a minimum of two supervisory personnel from the CSA, and document compliance with this requirement. Alternatively, the CTR shall provide a written letter from the CSM stating that the application personnel (listed by name) who shall perform coating work are approved by the CSM without further or additional training.
b. Provide training for all application personnel and three supervisory personnel. The training shall include the following as a minimum:
1) A detailed explanation of mixing, application, curing, and termination details.
2) Hands-on demonstration of how to mix and apply the coating systems.
3) A detailed explanation of the ambient condition requirements (temperature and humidity) and surface preparation requirements for application of the coating system as well as a detailed explanation of re-coat times, cure times, and related ambient condition requirements.

c. CTR shall provide a written statement that training was satisfactorily completed by the personnel named in the letter.

3. Representative Coating System Inspections:
   a. The CTR shall perform or witness the following activities to confirm acceptability and conformance with the specifications for representative portions of coating work to be performed by the CSA. The CTR shall verify or witness the contractors QC processes of the following QC steps at their discretion:
      1) Inspect ambient conditions during various coating system installation at hold points for conformance with the specified requirements.
      2) Inspect the surface preparation of the substrates where the coating system will terminate or will be applied for conformance to the specified application criteria.
      3) Inspect preparation and application of coating detail treatment (for example, terminations at joints, metal embedment's in concrete, etc.).
      4) Inspect application of the filler/surface materials for concrete and masonry substrates.
      5) Inspect application of the primers, stripe coats, and finish coats including wet and dry film thickness of the coatings.
      6) Inspect coating systems for cure.
      7) Review adhesion testing of the cured coating systems for conformance to specified criteria.
      8) Review coating system discontinuity testing for conformance to specified criteria.
      9) Observe adhesion testing work to assure it meets specification requirements.
      10) Inspect and record representative localized repairs made to discontinuities identified via continuity testing.
      11) Conduct a final review of completed coating system installation for conformance to the specifications.
   b. Prepare and submit a site visit report following each site visit that documents the acceptability of the coating work observed and inspected in accordance with the CSM's Recommendations.
4. Final Report:
   a. Upon completion of coating work for the project, the CTR shall prepare a letter summarizing the inspection findings and shall attach the site visit reports required in 1.05. Include a statement that the completed work was performed in accordance with the requirements of this Section 09 97 00 and the CSM's recommendations based on the inspections performed by the CTR.

1.06 DELIVERY AND STORAGE

A. General:
   1. Deliver materials to the job site in their original, unopened containers. Properly label each container. Handle and store materials to prevent damage to or loss of label.
   2. Include the following information on material container labels:
      a. Name or title of product.
      b. CSM's batch number.

c. CSM's name.
d. Generic type of material.
e. Application and mixing instructions.
f. Hazardous material identification label.
g. Shelf-life expiration date.

3. Store materials in enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations. Store flammable materials in accordance with state and local requirements.
4. Clearly mark containers shall indicating personnel safety hazards associated with the use of or exposure to the materials.
5. Provide Safety Data Sheets (SDS) for each material to the Construction Manager.

1.07 SUBMITTALS:

A. Action Submittals: Refer to related sections in this specification for additional details.
1. Procedures: Section 01 33 00.
2. A copy of this specification section, with addendum updates included, and referenced and applicable sections, with addendum updates included, with each paragraph check-marked (☑) to indicate specification compliance or marked to indicate requested deviations from specification requirements or those parts which are to be provided by the CSA or others. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CSA, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner's representative shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined shall signify compliance on the part of the CSA with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations to the specification requirements shall be cause for rejection of the entire submittal and no further submittal material will be reviewed. *Unapproved field deviations to project requirements may be deemed as non-conforming work.*
3. CSM's current printed recommendations and product data sheets for coating systems including:
a. Volatile organic compound (VOC) data.
b. Surface preparation recommendations.
c. Primer type, where required.
d. Maximum dry and wet-mil thickness per coat.
e. Minimum and maximum curing time between coats, including atmospheric conditions for each.
f. Curing time before submergence in liquid.
g. Thinner to be used with each coating.
h. Ventilation requirements.
i. Minimum atmospheric conditions during which the paint shall be applied.
j. Allowable application methods.
k. Maximum allowable moisture content.

l. Maximum shelf life.

4. Affidavits signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements.
5. Safety Data Sheets (SDS) for materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.
6. Written list of cleaning and thinner solutions allowed by the CSMs.
7. Storage requirements including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
8. CSM's detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including pipe penetrations, metal embedment's, gate frames, and other terminations to be determined from the contract drawings. This information shall also include detail treatment for coating system at joints and cracks in concrete.
9. List of a minimum of five project references each for Contractor and CSA including contact name, address, and telephone number where similar coating work has been performed by their companies in the past five years.
10. Resume of and written certification that the CSA's Quality Control Person is a AMMP (SSPC or NACE) Certified Coatings Inspector who has the requisite experience identified in Article 1.05.
11. Written Quality Control Testing and Inspection Plan (QCTIP) as required in Article 1.05.
12. Sample Daily Quality Control Inspection Report Forms to be used by the CSA's QCP.
13. Written letter from the CTR that the CSA's personnel who will perform the coating work have been trained to perform the work covered by this section.
14. Signed Affidavit from CSM that all products provided for the coating work covered by this Section are compliant with applicable VOC regulations.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Prior to application of coatings, submit letter(s) from the CTR(s) identifying the application personnel who have satisfactorily completed training as specified in Article 1.05 or a letter from the CSM stating that personnel who shall perform the work are approved by the CSM without need for further or additional training.
   3. Submit reports specified in Article 1.05 when the work is underway.

C. Closeout Submittals:
   1. Procedures: Section 01 33 00.
   2. Submit the Coating System Quality Control Checklists, using Form 09 97 00-A, for the coating work.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Notwithstanding the listing of product names in this Section, provide affidavits, signed and sealed by an officer of the CSM's corporation, attesting to full compliance

of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements. Do not apply coatings to a surface until the specified affidavits have been submitted, reviewed and accepted. Failure to comply with this requirement shall be cause for rejection and removal of such materials from the site.

2. The following list specifies the material requirements for coating systems. Coating systems are categorized by generic name followed by an identifying abbreviation. If an abbreviation has a suffix number, it is for identifying subgroups within the coating system.

B. For the specific Finish Schedule, refer to [Section 09 90 00] [Article 3.08].

Material Requirements for Potable Water Coating Systems for Steel Tanks: All North America Except SCAQMD in California

Coating System	CSM	Pit Filler	Primer Coat(s)	Stripe Coat(s)/ Intermediate	Finish Coats
INT-PWS-1 (AWWA D102-21 ICS#3)	Carboline	Carboguard 501	**No zinc primer available	Hydroplate 1100	Hydroplate 1100
	Induron	*Aquatapoxy A6 (Thick)	Indurazinc MC67 (Optional)	PE -70	Perma-Clean 100
	PPG	Aquatapoxy A6 (Thick)	Amercoat 68HS (Optional)	Amerlock 2/400	Aquatapoxy A6
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K (Optional)	SherPlate 600	Sherplate PW or Dura-Plate UHS
	Tnemec	Series 215	Hydro-Zinc 94-H20 (Optional)	Epoxoline Series 21	Epoxoline FC22 or Epoxoline 22
INT-PWS-2 (AWWA D102-21 ICS#4)	Carboline	Carboguard 501	**No zinc primer available	Reactamine 760	Reactamine 760
	PPG	Aquatapoxy A6 (Thick)	Amercoat 68HS (Optional)	Amerlock 2/400	AquataFlex 505
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K (Optional)	SherPlate 600	Poly-Cote 115
	Tnemec	Series 215	Hydro-Zinc 94-H20 (Optional)	Epoxoline Series 21	Elasto-Shield Series 406
INT-PWS-3 (AWWA D102-21 ICS#5)	Carboline	Carboguard 501	Carbozinc 621PW	Hydroplate 1086	Hydroplate 1086
	Induron	*Aquatapoxy A6 (Thick)	Indurazinc MC67	**PE-70	PE-70
	PPG	Aquatapoxy A6 (Thick)	Amercoat 68HS	Amerlock 2/400	Amerlock 2/400
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K	SherPlate 600	SherPlate 600
	Tnemec	Series 215	Hydro-Zinc 94-H20	Epoxoline Series 21	Epoxoline Series 21
INT-PWS-4 (AWWA D102-21 ICS#6)	Carboline	Carboguard 501	Carbozinc 621 PW	Hydroplate 1086 (Stripe Coat)	Hydroplate 1086
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K	Macropoxy 5500LT (Stripe Coat)	Macropoxy 5500LT
	Tnemec	Series 215	Hydro-Zinc 94-H20	Epoxoline Series 21 (Stripe Coat)	Epoxoline Series 21

Material Requirements for Potable Water Coating Systems for Steel Tanks: All North America Except SCAQMD in California

EXT-PWS-1 (AWWA D102-21 OCS #4)	Carboline	Carboguard 501	Carbozinc 859	Carbothane 133	Carboxane 950 VOC
	Induron	*Aquatapoxy A6 (Thick)	Indurazinc MC67	Permastic LV	Perma-Gloss LV
	PPG	Amercoat 114A	Amercoat 68HS	Durathane	Coroflon ADS
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K	Hi-Solids Polyurethane 250	Fluorokem HS 100
	Tnemec	Series 215	Hydro-Zinc 94-H20	Endura-shield 1095	Hydroflon V700
EXT-PWS-2 (AWWA D102-21 OCS #5)	Carboline	Carboguard 501	Carboguard 890	Carboguard 890	Carbothane 134 VOC
	Induron	*Aquatapoxy A6 (Thick)	**PE-70	**PE-70	Permastic LV
	PPG	Amercoat 114A	Amerlock 2/400	Amerlock 2/400	Pitthane Ultra Series
	Sherwin Williams	Steel Seam FT910	Macropoxy 646FC	Macropoxy 646FC	Hi-Solids Polyurethane 250 Gloss or
	Tnemec	Series 215	Pota-Pox Plus L140	Pota-Pox Plus L140	Endura-shield 1094
EXT-PWS-3 (AWWA D102-21 OCS #6)	Carboline	Carboguard 501	Carbozinc 859	Carboguard 635 VOC	Carbothane 134 VOC
	Induron	*Aquatapoxy A6 (Thick)	Indurazinc MC67	PE-70	Permastic LV
	PPG	Amercoat 114A	Amercoat 68HS	Amerlock 2/400	Pitthane Ultra Series
	Sherwin Williams	Steel Seam FT910	Corothane Galvapac 1K	Macropoxy 646FC	Hi-Solids Polyurethane 250 Gloss or
	Tnemec	Series 215	Hydro-Zinc 94-H20	Pota-Pox Plus L140	Endura-shield 1094
Over-Coating Systems	**CSM**	**Pit Filler**	**Tie Coat/Primer**	**Spot Primer/Intermediate**	**Finish Coat**
***EXT OCS-1	Carboline	Carboguard 501	Rustbond	Carboguard 890 (Spot Prime)	Carbothane 134 VOC
	Induron	*Aquatapoxy A6 (Thick)	Ebond	PE-70 (Spot Prime)	Permastic LV
	PPG	Amercoat 114A	Amerlock Sealer	Amerlock 2/400 (Spot Prime)	Pitthane Ultra Series
	Sherwin Williams	Steel Seam FT910	Macropoxy 5000	Macropoxy 646FC (Spot Prime)	Hi-Solids Polyurethane 250 Gloss or or Sherloxane 800 Gloss
	Tnemec	Series 215	Probond 3600	Pota-Pox Plus L140 (Spot Prime)	Endura-shield 1094
***EXT OCS-2	Carboline	Carboguard 501	NA	Carboguard 890 (Full Prime)	Carbothane 134 VOC

Material Requirements for Potable Water Coating Systems for Steel Tanks: All North America Except SCAQMD in California

	Induron	*Aquatapoxy A6 (Thick)	NA	PE-70 (Full Prime)	Permastic LV
	PPG	Amercoat 114A	NA	Amerlock 2/400 (Full Prime)	Pitthane Ultra Series or PSX 700
	Sherwin Williams	Steel Seam FT910	NA	Macropoxy 646FC (Full Prime)	Hi-Solids Polyurethane 250 Gloss or or Sherloxane 800 Gloss
	Tnemec	Series 215	NA	Chem-Build 135 (Full Prime)	Endura-shield 1094
***EXT OCS-3	Carboline	Carboguard 501	Rustbond	Carboguard 890 (Spot Prime)	Carbocrylic 3359 DTMC
	Induron	*Aquatapoxy A6 (Thick)	Ebond	PE-70 (Spot Prime)	Aquanaut II Acrylic
	PPG	Amercoat 114A	Amerlock Sealer	Amerlock 2/400 (Spot Prime)	Pitt-Tech Plus *(Max 72 Hr. Recoat)
	Sherwin Williams	Steel Seam FT910	Macropoxy 5000	Macropoxy 646FC (Spot Prime)	Shercryl HPA Acrylic
	Tnemec	Series 215	Probond 3600	Pota-Pox Plus L140 (Spot Prime)	Enduratone 1028

See CSM's Product Data Sheets for acceptable thinners for VOC compliance or do not thin.

**Induron purchases their pit filler from PPG. It is the same product.*

***No zinc primer available.*

**** Test patches shall be applied to confirm compatibility with existing system.*

Material Requirements for Potable Water Coating Systems for Concrete Tanks: All North America Except SCAQMD in California

Coating System	CSM	Parge Coat/Filler	Primer	Finish Coat (s)
INT-PWC-1	Carboline	Carbocrete 4010 or Carboguard 510	NA	Hydroplate 1100
	Induron	Mortarchem or *Aquatapoxy A6 (Thick)	NA	Perma-Clean 100
	PPG	Raven 760 EMC	NA	Aquatapoxy A6
	Sherwin Williams	Dura-Plate 2300, Steel Seam FT 910 or A.W Cook Products	NA	Sher-Plate PW, Dura-Plate UHS
	Tnemec	Series 218, Series 217, Series 215	NA	Series FC22 or Epoxoline 22
INT-PWC-2	Carboline	Carbocrete 4010 or Carboguard 510	NA	Reactamine 760
	PPG	PPG Raven 760 EMC	NA	AquataFlex 505
	Sherwin Williams	Dura-Plate 2300, Steel Seam FT 910 or A.W Cook Products	NA	Polycote 115

Material Requirements for Potable Water Coating Systems for Concrete Tanks: All North America Except SCAQMD in California

	Tnemec	Series 218, Series 217, Series 215	NA	Elasto-Shield 406
INT- PWC-3	Sherwin Williams	Dura-Plate 2300, Steel Seam FT 910 or A.W Cook Products	Dura-Plate UHS (Clear) with 1.5 oz Fiberglass Matt Embedded	2 Coats Dura-Plate UHS Pigmented.
	Tnemec	Series 218, Series 217, Series 215	Series 215 with 3/4 oz Fiberglass Matt Embedded	Epoxoline Series 22 Pigmented
EXT-PWC-1	Carboline	Carbocrete 4010, Carboguard 510, 501	Flexxide Elastomer	Flexxide Elastomer
	Induron	Mortarchem	AC 403S	AC 403S
	PPG	Megaseal CR	Perma-Crete Concrete and Masonry Surfacer	Perma-Crete Concrete and Masonry Surfacer
	Sherwin Williams	Dura-Plate 2300, Steel Seam FT 910 or A.W Cook Products	Loxon XP	Loxon XP
	Tnemec	Series 218, Series 215	Series 151-1051 Elasto-Grip FC	Series 156 or 157 Envior-Crete
EXT-PWC-2	Benjamin Moore	As per manufacturer's Instructions	Fresh Start Multipurpose Primer F023	2 coats- Ben Acrylic Latex Flat K541
	Carboline	Carbocrete 4010, Carboguard 510, 501	Carbocrylic 3359 Flat	2 Coats- Carbocrylic 3359 Flat
	PPG	Megaseal CR	Perma-Crete Concrete and Masonry Surfacer	2 coats- Speedhide 6-610X Acrylic Latex Flat
	Sherwin Williams	Dura-Plate 2300 or A.W Cook Products	Loxon Concrete & Masonry Primer	2 coats- A-100 Acrylic Latex Flat
	Tnemec	Series 218, Series 215	Series 180 Tneme-Crete WB	Series 180 Tneme-Crete WB
Overcoat Systems	**Carboline**	**Spot Primer**	**Intermediate Coat**	**Finish Coats**
***EXT OCC-1	Carboline	Flexxide Elastomer	Flexxide Elastomer	Flexxide Elastomer
	Induron	AC 403S	AC 403S	AC 403S
	PPG	Perma-Crete 4-100 Concrete Primer	Perma-Crete 4-110	Perma-Crete 4-110
	Sherwin Williams	Loxon Concrete & Masonry Primer	Loxon XP	Loxon XP
	Tnemec	Series 218, Series 215	Series 151-1051 Elasto-Grip FC	NA
***EXT OCC-2	Carboline	Carbocrylic 3359 Flat	Carbocrylic 3359 Flat	Carbocrylic 3359 Flat
	Induron	NA	NA	NA
	PPG	Perma-Crete 4-100 Concrete Primer	Speedhide 6-610X Acrylic Latex Flat	Speedhide 6-610X Acrylic Latex Flat
	Sherwin Williams	Loxon Concrete & Masonry Primer	Series A-100 Flat	Series A-100 Flat
	Tnemec	Tnemec 1026 Enduratone	Tnemec 1026 Enduratone	Tnemec 1026 Enduratone

Recommended Standard Coating Systems for Concrete Water Storage and Concrete In Water Treatment Facilities

INT-PWC-1	Amine Cured Epoxy – For Concrete Immersed in Potable Water – Plural Application Only

Recommended Standard Coating Systems for Concrete Water Storage and Concrete In Water Treatment Facilities	
INT-PWC-2	Aromatic Elastomeric Polyurethane-For Concrete immersed in Potable Water
INT-PWC-3	Epoxy Fiberglass Matt Layup System for Membrane Filtration Systems
EXT-PWC-1	Acrylic Elastomeric Coating
EXT-PWC-2	Acrylic Coating
EXT-OCC-1	Acrylic Elastomeric Coating
EXT-OCC-2	Acrylic Coating

PART 3 EXECUTION

3.01 COATINGS

A. General:
   1. Do not use coating products until the Owner's Representative has accepted the affidavits specified in articles 1.04 and 2.01, and inspected the materials, and the CTR has trained the CSA in the surface preparation, mixing and application of each coating system.
   2. Erect and maintain protective enclosures as stipulated per SSPC-Guide 6 Guide for Containing Debris Generated During Paint Removal Operations.

B. Shop and Field Coats:
   1. Shop Applied Prime Coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Use only shop-applied primer compatible with the specified coating system and apply at the minimum dry film thickness recommended by the CSM. Provide data sheets identifying the shop primer used to the CTR and the CSA. Performa adhesion tests on the shop primer as specified in Article 3.01.. Remove damaged, deteriorated, and poorly applied shop coatings that do not meet the requirements of this Section and the surfaces recoated. If the shop primer coat meets the requirements of this Section, the field coating may consist of touching up the shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity. The same quality control and quality assurance inspections are applicable for shop applications as for field applications.
   2. Field Coats: Apply field coats consisting of one or more prime coats and one or more finish coats to build up the coating to the specified dry film thickness. Unless otherwise specified, do not apply finish coats until other work in the area is complete and previous coats have been inspected.
   3. Adhesion Confirmation: Perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that (1) the shop applied prime coat adheres to the substrate, and (2) the specified field coatings adhere to the shop coat. Test results showing an adhesion rating of 5A on immersed surfaces and 4A or better on other surfaces are required for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 5B on immersed surfaces and 4B or better on other surfaces are required for coating thicknesses less than 5 mils.

C. Application Location Requirements:
   1. Equipment, Non-immersed: Items of equipment, or parts of equipment that are not immersed in service, shop prime and then finish coat in the field after installation

with the specified or acceptable color. If the shop primer requires top coating within a specified period, finish coat the equipment in the shop and then touch-up paint after installation. If equipment removal and reinstallation is required for the project, touch-up coat in the field following reinstallation.

2. Equipment, Immersed: Items of equipment, or parts and surfaces of equipment that are immersed when in service, with the exception of pumps and valves, shall have surface preparation and coating work performed in the field. Coating systems applied to immersed equipment shall be pinhole free.

3.02 PREPARATION

A. General:

1. Prepare surfaces for each type of surface in accordance with the specific requirements of each coating specification sheet (COATSPEC) and the following. In the event of a conflict, the COATSPEC sheets shall take precedence.
2. Clean and dry surfaces to be coated. Before applying coating or surface treatments, remove oil, grease, dirt, rust, loose mill scale, old weathered coatings, and other foreign substances. Remove oil and grease before mechanical cleaning is started. Where mechanical cleaning is accomplished by blast cleaning, wash, grade, and free the abrasive from contaminants that might interfere with the adhesion of the coatings. Use air for blast cleaning that is sufficiently free of oil and moisture so as not to cause detrimental contamination of the surfaces to be coated.
3. Where deemed necessary by the Owner's Quality Assurance representative, an AMPP (Formerly NACE/SSPC) Coatings Inspector with a minimum current Certified (Formerly Level 2) or Senior (Formerly Level 3) designation in good standing, provided by the Owner, will review surfaces to be coated before application of a coating. Surface defects identified by the inspector shall be corrected by the CSA at no additional cost to the Owner.
4. Protect all surfaces and equipment not to be coated from dust and overspray. Schedule cleaning and coating so that dust and spray from the cleaning process shall not fall on wet, newly coated surfaces. Remove or mask hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces prior to surface preparation and coating operations. Reinstall removed items following completion of coating. Disconnect and move equipment adjacent to walls to permit cleaning and coating of equipment and walls. Replace and reconnect items following coating.
5. Heating and Dehumidification: Install weather protection, including Dehumidification and heating devices, in compliance comply with all safety regulations including provisions for adequate ventilation and fire protection devices. Do not use heating devices which may cause damage to finish surfaces. Use indirect, fired diesel operated heating equipment or approved equivalent.
6. Dehumidification equipment shall be sized by the manufacturer of the equipment to ensure optimum operation and environmental control.
7. Quality Assurance Inspector Access: Provide all points of access for inspection by the Owner's Inspector. Provide ventilation, ingress and egress, and other means necessary for the Owner's Inspector personnel to safely access the work areas.
8. Ventilation: Provide ventilation in accordance with ANSI/ASC 29.4. Provide ventilation taking into account of the Lower Explosive Limit (LEL) of the product being applied

and comply with applicable regulations. (The LEL is the minimum concentration of vapor in air, expressed as a percentage, that will ignite). Provide ventilation during abrasive blasting operations to ensure adequate visibility. Use flexible trunking to allow the point of extraction to be reasonably close to the personnel carrying out the blasting. During and after coating application, arrange the ventilation system and trunking such that "dead spaces" do not exist – especially from lower areas of tanks where solvent vapors will tend to accumulate. Ensure adequate fresh air is being introduced into the tank. Do not re-introduce abrasive dust, solvent vapor, etc. into the tank. Maintain a positive pressure, above normal atmospheric pressure, inside the tank. As a "rule of thumb", minimum fresh air supply/extraction should be in the approximate ratio of 4:3 but actual determination of need and related health and safety considerations are the responsibility of the Contractor.

B. Steel Repairs to Existing Structures:
   1. After the initial abrasive blast cleaning, conduct a condition assessment in conjunction with the Owner or Owner's Representative to assess any repair needs. All surfaces to be lined on the tank interior shall meet NACE SP0178-Section 5 Surface Finish Practices Standards.
   2. Pit Filling: Treat All pits designated for pit filling in the following manner:
      a. Back-roll or fill pit to produce a holiday free coating. Shallow pits treated by back-rolling the coating after it has been spray applied.
      b. Fill pits up to 1/4-inch deep using the specified pit filler material. Sand pit filler material smooth and prepare to ensure adhesion of lining material.
      c. Repair pits greater than 1/4-inch by plug welding or welding steel plates onto the surface depending on the size of the affected area. If welding a patch plate, use the same thickness as the tank plate over the spot to be repaired. Grind edges of holes smooth prior to installation of the plate. Use patch plates no smaller than 6-inch by 6-inch or 6 inches in diameter. Lap edges of the plate shall a minimum of 2 inches from the edge of the hole. Grind all patch plate edges to a 1/16-inch radius. Do not leave plates with sharp edges. Welding practices shall be acceptable to the Engineer. Install plates in accordance with API 653. Locate plates a minimum of 3 inches from existing weld seams. If the plate must overlap a weld seam, provide rectangular plates with radius corners and extend a minimum of 6 inches beyond the existing weld seam. Fully weld all plate repairs on all sides with continuous fillet welds. Use appropriate welding procedures (electrode size and heat input) at all repair areas considering the potential for those areas to be thin and subject to damage from welding.
   3. Clean all apparently deteriorated weld seams by an initial blast clean for inspection and notify the Engineer of all suspected area of corrosion, apparent losses, or undercut welds to determine if any weld requires repair prior to coating.

C. Interior Chipping and/or Grinding:
   1. All interior surfaces to be lined shall conform to NACE SP0178 Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service. Eliminate all irregular surfaces on the interior of the tank and appurtenances, including but not limited to surface protrusions, burrs, scars, sharp edges or corners, weld spatter, weld overlap, and rough weld beads, by chipping and/or grinding these irregular surfaces to a smooth curve to the satisfaction of the Construction Manager. Remove and grind flush the protruding parts of lugs or brackets. The objective of chipping and/or grinding is to eliminate irregular surfaces

to provide a surface that is sufficiently smooth for the application of a uniform thickness coating without voids and free from defects. This chipping and/or grinding is also intended to make it easier for the interior coating to pass the holiday test.

D. Blast Cleaning:
   1. Meet the following requirements for abrasive blast cleaning:
      a. Do not reuse blast abrasive.
      b. Filter compressed air used for blast cleaning and ensure it contains no condensed water and no oil. Clean moisture traps at least once every four hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment as per ASTM D4285.
      c. Install oil separators just downstream of compressor discharge valves and at the discharge of the blast pot discharges. Check and clean oil separators on the same frequency as the moisture traps as defined above per ASTM D4285.
      d. Regulators, gauges, filters, and separators must in use on compressor air lines to blasting nozzles at all times during this work.
      e. Install an air dryer or desiccant filter drying unit which dries the compressed air prior to blast pot connections. Use and maintain the dryer for the duration of surface preparation work.
      f. Use abrasive blast nozzles of the venturi or other high velocity type supplied with a minimum of 100 pounds per square inch gauge (psig) air pressure and sufficient volume to obtain the blast cleaning production rates and cleanliness specified.
      g. Provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.
      h. If, between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, reclean the surface by water blasting, re-blasting and abrasive blast cleaning until the specified degree of cleanliness is reclaimed.
      i. The Contractor is responsible for dust control and for protection of mechanical, electrical, and other equipment adjacent to and surrounding the work area.

E. Solvent Cleaning:
   1. Use emulsifying type solvent wash, solvent wipe, or cleaners , including but not limited to those used for surface preparation in accordance with SSPC SP-1 Solvent Cleaning, which emit no more than 340 g/l VOCs for Architectural and Industrial Maintenance (AIM) regions, 250 g/l for CARB regions, and 100 g/l for SCAQMD regions, contain no phosphates, is biodegradable, remove no zinc, and is compatible with the specified primer.
   2. Use only clean white cloths and clean fluids in solvent cleaning.

F. Metallic Surfaces:
   1. Internal Metallic surfaces intended for immersion shall meet NACE SP0178 regarding surface defects, weld spatter, and weld condition prior to abrasive blasting.
   2. Prepare metallic surfaces in accordance with applicable portions of the joint surface preparation specifications of the SSPC and NACE specified for each coating system.

See CoatSpec for each coating system in this Section. The profile depth of the surface to be coated shall be in accordance with the COATSPEC requirements in this Section measured by Method C of ASTM D4417. Select Blast particle size to produce the specified surface profile. Use solvent in solvent cleaning operations as recommended by the CSM.

3. Take the following steps if soluble chloride contamination is suspected or possible/plausible. Following initial blast cleaning of steel substrates, test for the presence of soluble chlorides using the retrieval and analysis method designated as Method 4.2.2. Adhesively Bonded Latex Patch or Cell as described in SSPC-TG15. Test in accordance with ISO 8502-6/8502-9 at the rate of 4 tests per 1,000 sq ft of steel surface area to be coated. The target threshold or tolerance conductivity level for soluble chloride contamination shall be approved in writing by the CSM's CTR for each product that is part of the application. Any interior areas of notable pitting shall be tested for chlorides.
4. Prepare metallic surfaces for degree of cleanliness shall be based upon comparison with SSPC-VIS1-89 (ASTM D2200), and as described in the COATSPEC for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection\, provide on the first day of cleaning operations abrasive blast metal reference panels to the standards specified for acceptance by the Construction Manager. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels accepted by the Construction Manager as meeting the requirements of the specifications shall be initialed by the CSA and Construction Manager and coated with a clear non-yellowing finish. One of these panels shall be prepared for each type of abrasive blasting to be used as the comparison standard throughout the project.
5. Blast cleaning requirements for steel, ductile iron, and stainless steel substrates are as follows:
    a. Prepare internal steel surfaces, including all areas subjected to splashing, intermittent immersion and continuous condensation such as the roof structure for immersion service in accordance with SSPC SP 10/NACE #2 (Near White Metal Blast Cleaning).
    b. Prepare internal dry areas (non-immersion) and external steel in accordance with SSPC SP 6/NACE #3 (Commercial Blast Cleaning).
    c. Prepare ductile iron piping surfaces, including fittings, in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05.
    d. Prepare stainless steel surfaces by abrasive blast cleaning in accordance with SSPC-SP16 to leave a clean uniform appearance with a minimum uniform surface profile of 1.5 to 2.5 mils.
    e. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate by vacuum cleaning to meet ISO 8502-3 Particle size 1 dust rating 1 prior to coating application.
    f. Test areas of pitting per this specification for the presence of soluble chloride contamination in accordance with SSPC Guide 15 with a maximum allowable conductivity of 30 micro-siemens/centimeters (cm) in accordance with current United States Coast Guard requirements.
    g. Prevent contamination of the surface after blasting from worker's fingerprints, deleterious substances on workers' clothing, or from atmospheric conditions.
    h. Continuously monitor and maintain ambient environmental conditions in the enclosure to ensure the degree of cleanliness is held and no "rust back" occurs prior to coating material application. Maintain surface temperatures a minimum

of 5 degrees Fahrenheit (F) above the dew point, and improving, at all times during final blasting and coating application.

G. Concrete Surfaces:

1. Inspect concrete surfaces prior to surface preparation and prepare concrete surfaces in accordance with SSPC-SP13/SPCAB1/NACE #6.
2. Prior to surface preparation for degree of cleanliness and profile, prepare substrate cracks, areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges, per CSM recommendations.
3. Evaluate the surface profile for prepared concrete surfaces to be coated by comparing the profile of the prepared concrete to the profile with the ICRI 310.2 (surface profile replicas). Prepare surface profile in accordance with the COATSPEC requirements and the CSM's recommendations.
4. Inspect prepared concrete substrates for surface cleanliness after cleaning, preparation, and/or drying, but prior to making repairs or applying a coat in the coating system. Reinspect repaired concrete surfaces for cleanliness prior to application of the coating system.
5. Prepare concrete substrates using methods such as dry abrasive blast cleaning, high, or ultra-high-pressure water blast cleaning in accordance with SSPC-SP-13/SP CAB1/NACE #6 to meet the following requirements:
    a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances .
    b. Open up air voids or bug holes to expose their complete perimeter by blast cleaning or other methods. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable.
    c. Concrete substrate must be dry prior to the application of filler/surface or coating system materials.
    d. Produce a concrete surface with a minimum pH of 9.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
    e. Following inspection of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt and spent abrasive (if dry blast cleaning is used) leaving a dust free, sound concrete substrate.
    f. Remove debris produced by blast cleaning from the structures to be coated and disposed of legally off site.
6. Should abrasive blast cleaning or high or ultrahigh pressure water jetting not remove degraded concrete, use chipping or other abrading tools to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Concrete substrates must be dry prior to the application of filler/surfacers or coating system materials.
7. Test moisture content of concrete to be coated in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method at least once for every 500 sq ft of surface area to be coated or more often if required by the CSM. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test.

8. If moisture is detected the CSA in cooperation with the CTR shall perform additional moisture testing vis ASTM F1869 or ASTM F2170 to determine the extent of the moisture vapor transmission. Acceptable limits for the application of barrier coatings for ASTM F1869 is <3 pounds/1,000 sq ft/24 hours. Acceptable limits as per ASTM F2170 is an RH value <70 percent.

3.03 APPLICATION

A. Workmanship:
   1. Coated surfaces shall be free from runs, drips, ridges, waves, laps, and brush marks. Apply coats to produce an even film of uniform thickness completely coating corners and crevices.
   2. Use equipment designed for application of the materials specified. Equip compressors with suitable traps and filters to remove water and oils from the air. Perform a paper blotter test when requested by the Construction Manager to determine if the air is sufficiently free of oil and moisture so as not to produce deteriorating effects on the coating system. Control the amount of oil and moisture in spray air to be less than the amount recommended by the CSM. Equip spray equipment with mechanical agitators, pressure gages, and pressure regulators, and spray nozzles of the proper sizes.
   3. Apply each coat evenly and sharply cut to line. Avoid over-spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
   4. Use coating applications method recommended by CSM.
   5. Allow each coat to cure or dry thoroughly, according to CSM's printed instructions, prior to recoating.
   6. Vary color for each successive coat for coating systems when possible.
   7. When coating complex steel shapes, prior to overall coating system application, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer coat as a separate coat using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties, Mixing and Thinning:
   1. Coatings, when applied, shall provide a satisfactory film and smooth even surface. Sand glossy undercoats to provide a surface suitable for the proper application and adhesion of subsequent coats. Thoroughly stir, strain, and keep at a uniform consistency all coating materials during application. Mix Coating materials consisting of 2 or more components in accordance with the CSM's instructions. Where necessary to suit the conditions of the surface, temperature, weather and method of application, the coating may be thinned immediately prior to use as recommended by the CSM. The VOC of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, do not reduce coatings more than necessary to obtain the proper application characteristics. Use thinner as recommended by the CSM.

C. Atmospheric Conditions:
   1. Apply coatings only to surfaces that are dry, and only under conditions of evaporation rather than condensation. Do not apply coatings systems during rainy, misty weather, or to surfaces upon which there is frost or moisture condensation. During damp

weather, when the temperature of the surface to be coated is within 5 degrees F of the dew point or risk of this within 4 hours of completion, forced dehumidification equipment may be used to maintain a surface temperature of minimum 40 degrees F and 5 degrees F above the dew point for the surfaces to be coated, the coated surface, and the atmosphere in contact with the surface, unless approved in writing from the CSM's technical department. Maintain these conditions for a period of at least 8 hours or as recommended by the CSM. Where conditions causing condensation are severe, use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain the required atmospheric and surface temperature requirements for proper coating application and cure.

D. Concrete Substrate Temperatures and Detail Treatment:
   1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, and/or blistering in the coating system. The application of the filler/surface and the coating system will only be allowed during periods of falling temperature. This will require that application of the filler/surface and coating system only occur during the cooler evening hours. Include all cost for working outside of normal hours in the bid.
   2. Repair all bubbles, pinholes, or discontinuities that form in the applied coating system material as recommended by the CSM prior to installation of any additional coats. Should pinholes develop in the filler/surfacer material or in the first coat of the coating material, the pinholes shall be repaired in accordance with the CSM's recommendations prior to application of the next coat of material. Open up and completely fill air voids behind or beneath each with the specified filler/surfacer material. Abrade the coated area around the pinhole repair recoat that area.
   3. Perform application detail work per CSM's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:
   1. Do not handle, work on, or otherwise disturb, until the coating is completely dry and hard. Recoat or retouch shop-coated items after delivery at the site, and upon permanent erection or installation with specified coating when it is necessary to maintain the integrity of the film.

F. Method of Coating Application:
   1. Use equipment and methods for applying coatings and linings approved in writing by the CSM.
   2. Where two or more coats are required, provide sufficient compatible color additive, or contrasting color, in alternate coats to act as indicator of coverage.
   3. Do not apply coatings to a surface until it has been prepared as specified.

G. Film Thickness and Continuity:
   1. Verify WFT of the first coat of the coating system and subsequent coats , following application of each coat.
   2. Do not exceed the surface area covered per gallon of coating for various types of surfaces recommended by the CSM. The first coat, referred to as the prime coat, on metal surfaces refers to the first full paint coat and not to solvent wash, grease

emulsifiers, or other pretreatment applications. Apply coatings to the thickness specified, and in accordance with these specifications.

3. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may need to be applied to achieve the specified dry film thickness.
4. For concrete substrates, appropriately prepare the surface per requirements and apply a complete skim coat of the specified filler/surfacer material over the entire substrate prior to application of the coating system where necessary. Apply the skim coat as recommended by the CSM such that all open-air voids and bug-holes in the concrete substrate are completely filled prior to coating application.

H. Special Requirements:

1. Before erection, apply all coats to interior surfaces of steel supports, pipe hangers, piping in contact with hangers, and contact surfaces that are inaccessible after assembly. Hand clean or power-tool clean areas damaged during erection and recoat with primer coat prior to the application of subsequent coats. Touch-up surfaces after installation. Verify surfaces to be coated are clean and dry at the time of application.

I. Electrical and Instrumentation Equipment and Materials:

1. Electrical and instrumentation equipment and materials shall be coated in accordance with Section 09 90 00.

3.04 CLEANUP

A. General:

1. Upon completion of coating, remove surplus materials, protective coverings, and accumulated rubbish, and thoroughly clean surfaces and repair overspray or other coating-related damage.

3.05 FINAL TESTING

A. QC/QA Verification Steps:

1. Complete all testing after full cure and prior to disinfection of tank.
2. All final testing is subject to observation by the Owner/Owner's Representative at the Owner's discretion. Inform the Engineer/Owner for scheduled final testing providing a minimum of 48 hours' notice.

B. Testing includes but is not limited to the following:

1. Visual inspection for complete hiding of previously applied coats
2. No excessive runs, sags, protrusions, or depressions
3. No dry spray or other surface defects
4. Solvent rub test as per ASTM D4752-20 to verify cure
5. Ensure no off-ratio material has been applied
6. Dry film thickness testing as per SSPC PA2 Level 3 (Steel) SSPC PA 9 Level (Concrete)
7. High Voltage holiday testing as per ASTM D5162-21 (Interior Lining Only, or other where exposed to liquid or vapor headspace – 100 percent of exposed surface area)
8. Finish texture of coatings shall be uniform

3.06 TANK DISINFECTION PROCEDURES

A. References:
   1. American Water Works Association (AWWA) Standards
   2. ANSI/AWWA C652-11, Disinfection of Water-Storage Facilities

B. Sequencing and Scheduling:
   1. The interior coating shall be properly cured.
   2. The interior coating shall be washed with potable water.
   3. CSA shall flush and disinfect the tank.
   4. The Owner shall take and send in the samples to the laboratory for testing.
   5. The Owner shall pay for the testing of the initial set of samples. The CSA shall pay for all subsequent samples and testing, if required.

3.07 COATING SYSTEM SPECIFICATION SHEETS (COATSPEC)

A. General:
   1. Coating systems for different types of surfaces and general service conditions for which these systems are normally applied are specified on the following COATSPEC sheets. Coat surfaces in accordance with the COATSPEC to the system thickness specified. Use coating systems as specified in paragraph 3.07. In case of conflict between the schedule and the COATSPECS, the requirements of the schedule take precedence.
   2. Coating Specification Sheets included in Table A are included in this paragraph 3.07.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Conditions
INT-PWS-(Meets AWAA D102 21 ICS#3)	(Optional) Zinc Rich Primer with 100% Solids Amine Cured Epoxy Finish Coat	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
INT-PWS-2 (Meets AWWA D102-21-ICS #4)	Optional Zinc Rich Primer with 100% Solids Aromatic Elastomeric Polyurethane Finish Coat.	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
INT-PWS-35 (Meets AWWA D102-21-ICS#5)	Zinc Rich Primer with Polyamide or Polyamine or Modified Polyamine Cured Epoxy	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
INT-PWS-4 (Meets AWWA D102-21-ICS#6)	Zinc Rich Primer with Polyamide or Polyamine or Modified Polyamine Cured Epoxy	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation
EXT-PWS-1 (Meets AWWA D102-21-OCS#4)	Zinc Rich Primer/Aliphatic Urethane/Fluoropolymer Urethane	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
EXT-PWS-2 (Meets AWWA D102-21-OCS #5)	Polyamide or Polyamine or Modified Polyamine Cured Epoxy/Aliphatic Urethane	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel	Atmospheric exposure of Tank Exterior for corrosion and UV protection.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Conditions
EXT-PWS-3 (Meets AWWA D102-21-OCS #6)	Zinc Rich Primer/ Polyamide or Polyamine or Modified Polyamine Cured Epoxy/Aliphatic Urethane	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
EXT-OCS-1 (Exterior Overcoat System on Previously Coated Steel Tanks)	Epoxy Spot Prime/Epoxy Penetrating Sealer/Urethane or Polysiloxane	Previously Coated Steel Surfaces	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
EXT-OCS-2 (Exterior Overcoat System on Previously Coated Steel Tanks)	Epoxy Spot Prime/Epoxy Intermediate/Urethane or Polysiloxane	Previously Coated Steel Surfaces	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
EXT-OCS-3 (Exterior Overcoat System on Previously Coated Steel Tanks)	Epoxy Spot Prime/Epoxy Penetrating Sealer/Acrylic	Previously Coated Steel Surfaces	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
INT-PWC-1	Amine or Novolac Cured Epoxy System	Concrete	Concrete Substrates Subject to Constant Immersion In Potable Water
INT-PWC-2	Aromatic Elastomeric Polyurethane	Concrete	Concrete Substrates Subject to Constant Immersion In Potable Water
INT-PWC-3	Amine Cured Epoxy Fiberglass Layup System	Concrete	Concrete Substrates Subject to Constant Immersion in Potable Water in Membrane Filtration Systems.
EXT-PWC-1	Acrylic Elastomeric	Concrete	Concrete Substrates Subject to Exterior Exposures and UV
EXT-PWC-2	Acrylic	Concrete	Concrete Substrates Subject to Exterior Exposures and UV
EXT-OCC-1	Acrylic Elastomeric	Previously Painted/Coated Concrete	Concrete Substrates Subject to Exterior Exposures and UV
EXT-OCC-2	Acrylic	Previously Painted/Coated Concrete	Concrete Substrates Subject to Exterior Exposures and UV

Coating System Specification Sheets (COATSPEC)

Coating System Identification—INT-PWS-(Meets AWAA D102 21 ICS#3)

1. Coating Material:	(Optional) Zinc Rich Primer with 100% Solids Amine Cured Epoxy Finish Coat
2. Surface:	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel
3. Service Conditions:	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
4. Surface Preparation:	
a. Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10.If applying finish coat direct to metal with no primer, achieve a minimum surface profile of 3.0 to 4.0 mils. If using a zinc primer, achieve a minimum surface profile of 2.0-3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
b. Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a

Coating System Specification Sheets (COATSPEC)

Coating System Identification—INT-PWS-(Meets AWAA D102 21 ICS#3)

		1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
	c. Galvanized Steel:	DO NOT USE GALVANIZED STEEL in Potable Water Immersion Service.
	d. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
	e. Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
	f. Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with an NSF 600/61 approved polysulfide or polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:	
	a. Coating System Thickness:	20-40 DFT (22.5–42.5 if Zinc Primer Used).
	b. Coatings:	1 or 2 coat system (If using Zinc Primer).
	c. Primer (Optional):	One coat of zinc rich primer at 2.5 mils or per CSM's recommended DFT.
	d. Finish Coats:	One coat at CSM's recommended DFT to achieve the total system DFT.
	e. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
	f. Post Cure QC Testing:	Perform Holiday Detection over 100% of the coated surface area in accordance with ASTM D5162. Acceptance Criteria–no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
	g. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area, feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-2 (Meets AWWA D102-21-ICS #4)

1.	Coating Material:	Optional Zinc Rich Primer with 100% Solids Aromatic Elastomeric Polyurethane Finish Coat.
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel
3.	Service Conditions:	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
4.	Surface Preparation:	
	a. Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10. If applying finish coat direct to metal with no primer achieve a minimum surface profile of 3.0 to 4.0 mils. If using a zinc primer, achieve a minimum surface profile of 2.0-3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
	b. Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP1 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
	c. Galvanized Steel:	DO NOT USE GALVANIZED STEEL in Potable Water Immersion Service.
	d. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
	e. Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
	f. Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with an NSF 600/61 approved polysulfide or polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2-inches in all directions.
5.	Field Application:	
	a. Coating System Thickness:	25-40 DFT (27.5 – 42.5 If Zinc Primer Used).
	b. Coatings:	1 or 2 coat system (If using Zinc Primer).
	c. Primer (Optional)	One coat of zinc rich primer at 2.5 mils or per CSM's recommended DFT.
	d. Finish Coats:	One coat at CSM's recommended DFT to achieve the total system DFT.
	e. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
	f. Post Cure QC Testing:	Perform Holiday Detection over 100% of the coated surface area in accordance with ASTM D5162. Acceptance Criteria–no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-2 (Meets AWWA D102-21-ICS #4)

g. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in two or three coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-35 (Meets AWWA D102-21-ICS#5)

1. Coating Material:	Zinc Rich Primer with Polyamide or Polyamine or Modified Polyamine Cured Epoxy
2. Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel
3. Service Conditions:	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation.
4. Surface Preparation:	
a. Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 2.0 to 3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
b. Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 and abrade the peripheral intact coating area around the bare metal by 1-1/2-inches all around for re-priming. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c. Galvanized Steel:	DO NOT USE GALVANIZED STEEL in Potable Water Immersion Service.
d. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e. Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
f. Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with an NSF 600/61 approved polysulfide or polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2-inches in all directions.
5. Field Application:	
a. Coating System Thickness:	10.5 – 12.5 mils DFT.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-35 (Meets AWWA D102-21-ICS#5)

b. Coatings:	3 Coat System.
c. Primer:	Primer-1 coat of zinc rich primer at minimum 2.5 mils or as per CSM's recommended DFT.
d. Intermediate Coat:	1 coat or more of epoxy at minimum 4.0 mils or as per CSM's recommended DFT.
e. Finish Coat:	1 coat or more of epoxy at minimum 4.0 mils or as per CSM's recommended DFT.
f. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g. Post Cure QC Testing:	Perform Holiday Detection over 100% of the coated surface area in accordance with ASTM D5162 Acceptance Criteria–no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
h. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2-inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-4 (Meets AWWA D102-21-ICS#6)

1. Coating Material:	Zinc Rich Primer with Polyamide or Polyamine or Modified Polyamine Cured Epoxy
2. Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Stainless Steel
3. Service Conditions:	Continuous Immersion in Potable Water Including tank shell, floor, roof structure, wet riser and other areas subjected to immersion or continuous Condensation
4. Surface Preparation:	
a. Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP10 to achieve a minimum surface profile of 2.0 to 3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
b. Shop Primed Metals:	DO NOT USE SHOP PRIMED COMPONENTS IN THIS SERVICE unless the shop primer's maximum recoat time has not been exceeded. If there is damage to the shop primer, power tool clean to bare metal all damaged areas in accordance with SSPC SP11 and abrade the peripheral intact coating area around the bare metal by 1-1/2 inches all around for re-priming. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWS-4 (Meets AWWA D102-21-ICS#6)

c.	Galvanized Steel:	DO NOT USE GALVANIZED STEEL in Potable Water Immersion Service.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e.	Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
f.	Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with an NSF 600/61 approved polysulfide or polyurethane to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2-inches in all directions.
5.	Field Application:	
a.	Coating System Thickness:	12.5 – 16.0 mils DFT.
b.	Coatings:	2 Coat System.
c.	Primer:	Primer-1 coat of zinc rich primer at min 2.5 mils or as per CSM's recommended DFT.
d.	Finish Coat:	1 coat of epoxy at min 10.0 mils or as per CSM's recommended DFT.
e.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
f.	Post Cure QC Testing:	Perform Holiday Detection over 100% of the coated surface area in accordance with ASTM D5162. Acceptance Criteria–no pinholes or holidays. Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
g.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1-inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-1 (Meets AWWA D102-21-OCS#4)

1.	Coating Material:	Zinc Rich Primer/Aliphatic Urethane/Fluoropolymer Urethane

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-1 (Meets AWWA D102-21-OCS#4)

2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel
3.	Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4.	Surface Preparation:	
a.	Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP6 to achieve a minimum surface profile of 2.0 to 3.0 mils. Vacuum clean to remove all dust, dirt, loose material (including all existing coatings if a complete recoating project).
b.	Shop Primed Metals:	Components Shop Primed with a Pre-Construction weldable zinc primer are acceptable providing verification that the pre-construction primer was applied to SSPC-SP6/NACE#3 blast cleaned steel surface. All welds and any areas damaged or affected by erection shall be blasted to meet a minimum SSPC-SP6/NACE#3 blast cleanliness standard. Sweep blasting is required if the shop primer's maximum recoat time has been exceeded. Surface profile for bare metal shall be 2.0-3.0 mils. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c.	Galvanized Steel:	Prepare all galvanized steel to be coated as per SSPC-SP16.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e.	Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
f.	Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:	
a.	Coating System Thickness:	6.5–10.0 mils DFT.
b.	Coatings:	3 Coat System.
c.	Primer:	Primer-1 coat of zinc rich primer at minimum 2.5 mils or as per CSM's recommended DFT.
d.	Intermediate:	1 coat of aliphatic urethane at minimum 2.0 mils or as per CSM's recommended DFT.
e.	Finish Coat:	1 coat of fluoropolymer urethane at minimum 2.0 mils or as per CSM's recommended DFT.
f.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g.	Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-1 (Meets AWWA D102-21-OCS#4)

h. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-2 (Meets AWWA D102-21-OCS #5)

1. Coating Material:	Polyamide or Polyamine or Modified Polyamine Cured Epoxy/Aliphatic Urethane
2. Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel
3. Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4. Surface Preparation:	
a. Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP6 to achieve a minimum surface profile of 2.0 to 3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
b. Shop Primed Metals:	Components Shop Primed with a Pre-Construction weldable zinc primer are acceptable providing verification that the pre-construction primer was applied to SSPC-SP6/NACE#3 blast cleaned steel surface. All welds and any areas damaged or affected by erection shall be blasted to meet a minimum SSPC-SP6/NACE#3 blast cleanliness standard. Sweep blasting is required if the shop primer's maximum recoat time has been exceeded. Surface profile for bare metal shall be 2.0-3.0 mils. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c. Galvanized Steel:	Prepare all galvanized steel to be coated as per SSPC-SP16.
d. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e. Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.
f. Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2-inches in all directions.
5. Field Application:	
a. Coating System Thickness:	6.5 – 10.0 mils DFT.
b. Coatings:	3 Coat System.
c. Primer:	1 coat of epoxy primer at min 2.5 mils or as per CSM's recommended DFT.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-2 (Meets AWWA D102-21-OCS #5)

d.	Intermediate:	1 coat of epoxy primer at min 2.0 mils or as per CSM's recommended DFT.
e.	Finish Coat:	1 coat of aliphatic urethane at min 2.0 mils or as per CSM's recommended DFT.
f.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g.	Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria–minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
h.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWS-3 (Meets AWWA D102-21-OCS #6)

1.	Coating Material:	Zinc Rich Primer/ Polyamide or Polyamine or Modified Polyamine Cured Epoxy/Aliphatic Urethane
2.	Surfaces:	Carbon Steel, Ductile Iron or Cast Iron, Galvanized Steel, Stainless Steel
3.	Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4.	Surface Preparation:	
a.	Carbon Steel:	Abrasive blast clean to Near White Metal Blast Degree of Cleanliness per SSPC SP6 to achieve a minimum surface profile of 2.0 to 3.0 mils. Vacuum clean to remove all dust, dirt, and loose material (including all existing coatings if a complete recoating project).
b.	Shop Primed Metals:	Components Shop Primed with a Pre-Construction weldable zinc primer are acceptable providing verification that the pre-construction primer was applied to SSPC-SP6/NACE#3 blast cleaned steel surface. All welds and any areas damaged or affected by erection shall be blasted to meet a minimum SSPC-SP6/NACE#3 blast cleanliness standard. Sweep blasting is required if the shop primer's maximum recoat time has been exceeded. Surface profile for bare metal shall be 2.0-3.0 mils. Abrading the intact primer must produce a 1.0 to 1.5 mil profile in the existing primer. Vacuum clean to remove all loose dust, dirt, and loose coating material.
c.	Galvanized Steel:	Prepare all galvanized steel to be coated as per SSPC-SP16.
d.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05. Vacuum clean as required for carbon steel.
e.	Stainless Steel Component Surfaces:	Abrasive blast clean in accordance with SSPC SP16 using only aluminum oxide abrasive blast media to produce a minimum, uniform surface profile of 1.5 to 2.5 mils. Vacuum clean the same as for carbon steel surfaces. Stainless steel is only to be prepared and coated when galvanic corrosion (dissimilar metal corrosion) is a concern.

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Coating System Identification – EXT-PWS-3 (Meets AWWA D102-21-OCS #6)

f.	Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:	
a.	Coating System Thickness:	6.5 – 10.0 mils DFT.
b.	Coatings:	3 Coat System.
c.	Primer:	1 coat of zinc rich primer at min 2.5 mils or as per CSM's recommended DFT.
d.	Intermediate:	1 coat of epoxy primer at min 2.0 mils or as per CSM's recommended DFT.
e.	Finish Coat:	1 coat of aliphatic urethane at min 2.0 mils or as per CSM's recommended DFT.
f.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g.	Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D4541 at a minimum of 4 locations representative of all components making up the internal area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria – minimum 850 psi with failure plane at substrate for 75% of load fixture surface area. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
h.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCS-1 (Exterior Overcoat System on Previously Coated Steel Tanks)

1.	Coating Material:	Epoxy Spot Prime/Epoxy Penetrating Sealer/Urethane or Polysiloxane
2.	Surfaces:	Previously Coated Steel Surfaces
3.	Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4.	Surface Preparation:	
a.	General Considerations	Prior to surface preparation and coating application, Adhesion Testing in accordance with ASTM D3359 Method A (X-Cut Tape Adhesion Test) must be completed to verify substrate is suitable for overcoating. Minimum Acceptable Value of 4A required before proceeding.
b.	Previously Coated Carbon Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
c.	Areas of Corrosion: (Not including pinpoint	All localized corrosion areas shall be prepared by power tool cleaning to bare metal in accordance with SSPC SP11. Only coatings and tightly adherent corrosion that pass the Dull Putty Knife Test are allowed to remain on the surface. Abrade the

Coating System Identification – EXT-OCS-1 (Exterior Overcoat System on Previously Coated Steel Tanks)			
		or mild general corrosion)	peripheral intact coating area around the bare metal in accordance with SSPC-SP3 by 1-1/2 inches all around. Abrading the intact coating must produce a 1.0 to 1.5 mil profile in the existing coating. Vacuum clean to remove all loose dust, dirt, and loose coating material. After surface preparation all areas of remaining tightly adherent corrosion shall be spot primed with the specified epoxy spot primer at the specified DFT, prior to application of the tie coat primer to all surfaces.
	d.	Previously Coated Galvanized Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5,000-10,000 psi.
	e.	Cast Iron or Ductile Iron:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5,000-10,000 psi.
	f.	Previously Coated Stainless Steel Component Surfaces:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5,000-10,000 psi.
	g.	Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:		
	a.	Coating System Thickness:	6.0 – 8.5 mils DFT.
	b.	Coatings:	2 to 3 Coat System with Spot Primer depending on coverage and aesthetics.
	c.	Spot Primer:	1 coat of epoxy at a min of 3.0 – 4.0 mils or as per CSM's recommended DFT to all remaining tightly adherent corrosion.
	d.	Tie Coat:	1 coat of epoxy penetrating primer/sealer at min 1.0 – 1.5 mils or as per CSM's recommended DFT over all surfaces to be top coated.
	e.	Finish Coat:	1 or 2 coats (to complete coverage) of aliphatic urethane at min 2.0–3.0 mils per coat or as per CSM's recommended DFT.
	f.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
	g.	Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D3359 Method A at a minimum of 4 locations representative of all components making up the exterior area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria – minimum 4A. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
	h.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in 2 or 3 coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCS-2 (Exterior Overcoat System on Previously Coated Steel Tanks)

1.	Coating Material:	Epoxy Spot Prime/Epoxy Intermediate/Urethane or Polysiloxane
2.	Surfaces:	Previously Coated Steel Surfaces
3.	Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4.	Surface Preparation:	
a.	General Considerations:	Prior to surface preparation and coating application, Adhesion Testing in accordance with ASTM D3359 Method A (X-Cut Tape Adhesion Test) must be completed to verify substrate is suitable for overcoating. Minimum Acceptable Value of 4A required before proceeding.
b.	Previously Coated Carbon Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
c.	Areas of Corrosion: (Not including pinpoint or mild general corrosion)	All localized corrosion areas shall be prepared by power tool cleaning to bare metal in accordance with SSPC SP11. Abrade the peripheral intact coating area around the bare metal in accordance with SSPC-SP3 by 1-1/2 inches all around. Abrading the intact coating must produce a 1.0 to 1.5 mil profile in the existing coating. Vacuum clean to remove all loose dust, dirt, and loose coating material.
d.	Previously Coated Galvanized Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
e.	Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-03. Vacuum clean as required for carbon steel.
f.	Previously Coated Stainless Steel Component Surfaces:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
g.	Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5.	Field Application:	
a.	Coating System Thickness:	6.0 – 10 mils DFT.
b.	Coatings:	2 to 3 Coat System with Spot Primer depending on coverage and aesthetics.
c.	Spot Primer:	1 coat of epoxy at a min of 3.0 – 4.0 mils or as per CSM's recommended DFT to all remaining tightly adherent corrosion.
d.	Primer Coat:	1 coat of epoxy at a min of 4.0 – 6.0 mils or as per CSM's recommended DFT.
e.	Finish Coat:	1 or 2 coats (to complete coverage) of aliphatic urethane at min 2.0 – 3.0 mils per coat or as per CSM's recommended DFT.
f.	Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g.	Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D3359 Method A at a minimum of 4 locations representative of all components making up the exterior area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria – minimum 4A. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
h.	Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCS-2 (Exterior Overcoat System on Previously Coated Steel Tanks)

	materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in two or three coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

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Coating System Identification – EXT-OCS-3 (Exterior Overcoat System on Previously Coated Steel Tanks)

1. Coating Material:	Epoxy Spot Prime/Epoxy Penetrating Sealer/Acrylic
2. Surfaces:	Previously Coated Steel Surfaces
3. Service Conditions:	Atmospheric exposure of Tank Exterior for corrosion and UV protection.
4. Surface Preparation	
a. General Considerations:	Prior to surface preparation and coating application, Adhesion Testing in accordance with ASTM D3359 Method A (X-Cut Tape Adhesion Test) must be completed to verify substrate is suitable for overcoating. Minimum Acceptable Value of 4A required before proceeding.
b. Previously Coated Carbon Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
c. Areas of Corrosion: (Not including pinpoint or mild general corrosion)	All localized corrosion areas shall be prepared by power tool cleaning to bare metal in accordance with SSPC SP11. Abrade the peripheral intact coating area around the bare metal in accordance with SSPC-SP3 by 1-1/2 inches all around. Abrading the intact coating must produce a 1.0 to 1.5 mil profile in the existing coating. Vacuum clean to remove all loose dust, dirt, and loose coating material.
d. Previously Coated Galvanized Steel:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
e. Cast Iron or Ductile Iron:	Abrasive blast clean these surfaces in accordance with NAPF 500-03, NAPF 500-03-03. Vacuum clean as required for carbon steel.
f. Previously Coated Stainless Steel Component Surfaces:	Pressure Wash surface to SSPC WJ 4/NACE WJ 4 (HPWC) High Pressure Water Cleaning using 5000-10,000 psi.
g. Stainless Steel Fastener Surfaces: When stainless steel fasteners are electrically continuous with coated carbon steel.	Solvent clean all bolts, nuts, washers, etc. in accordance with SSPC SP1 to remove all traces of cutting oil. Stainless steel fasteners should be field coated with the ferrous metal components that the fasteners connect. Also, these fasteners shall be completely sealed with a polyurethane sealant to prevent future galvanic corrosion between the fasteners and the coated steel or other coated ferrous metal surfaces. The installation of the sealant shall be continued onto the coated ferrous metal surfaces by at least 2 inches in all directions.
5. Field Application:	
a. Coating System Thickness:	3.0 – 4.5 mils DFT.
b. Coatings:	2 to 3 Coat System with Spot Primer depending on coverage and aesthetics.
c. Spot Primer:	1 coat of epoxy at a min of 3.0 – 4.0 mils or as per CSM's recommended DFT to all remaining tightly adherent corrosion.
d. Tie Coat:	1 coat of epoxy penetrating sealer at a min of 1.0-1.5 mils or as per CSM's recommended DFT.
e. Finish Coat:	1 or 2 coats (to complete coverage) of high-performance acrylic at a min 2.0 – 3.0 mils per coat or as per CSM's recommended DFT.
f. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
g. Post Cure QC Testing:	Perform Adhesion Testing in accordance with ASTM D3359 Method A at a

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Coating System Identification – EXT-OCS-3 (Exterior Overcoat System on Previously Coated Steel Tanks)

	minimum of 4 locations representative of all components making up the exterior area of the tank. If coating applied to other metal equipment or components, perform number of adhesion tests per the CSM's recommendations. Acceptance Criteria – minimum 4A. Areas damaged by adhesion testing shall be repaired by the CSA at no additional cost to the Owner.
h. Pinhole, Holiday or Defect Repair Procedure:	Using a grinder or flapper wheel tool, remove the coating at defect or adhesion test area on areas of 1-1/2 inches in diameter to bare metal. Abrade the coating in area comprising periphery of bare metal to 1 inch all around the bare metal area to achieve a 1.5 to 2.0 mil profile in the existing intact coating in periphery area. Vacuum clean the prepared area to remove all loose dust, dirt, and loose coating materials leaving a clean, sound area for coating repair. Tape to mask the peripheral area at the edge of the roughened existing coating. Apply the coating system in two or three coats as necessary to achieve the total system DFT over the defect and coating prepared area feathering the coatings onto the roughened existing coating around the periphery of the repair area. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWC-1

1. Coating Material:	Amine or Novolac Cured Epoxy System
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates Subject to Constant Immersion In Potable Water
4. Surface Preparation:	
a. General Considerations:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP-6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete

Coating System Identification – INT-PWC-1

	surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified), it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP4 in accordance with ICRI 310.2R prior to coating application.
c. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats, or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Coating System Thickness:	50-60 mils dry film in addition to the parge coat.
c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
d. Post Cure QC Testing:	Holiday Detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 SF for verification purposes prior to commencing with production coating work), perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated, if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75% of failure plane on back of load fixture within the concrete substrate.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWC-1

e. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6-to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 30-40 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWC-2

1. Coating Material:	Aromatic Elastomeric Polyurethane
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates Subject to Constant Immersion In Potable Water
4. Surface Preparations:	
a. General Considerations:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length.

Coating System Identification – INT-PWC-2

	Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP-6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP4 in accordance with ICRI 310.2R prior to coating application.
c. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Coating System Thickness:	50-60 mils dry film in addition to the parge coat.
c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
d. Post Cure QC Testing:	Holiday Detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (Do mock-up of 200 square feet for verification purposes prior to commencing with production coating work),perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to

Coating System Specification Sheets (COATSPEC)

Coating System Identification – INT-PWC-2

	be coated, if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75% of failure plane on back of load fixture within the concrete substrate.
e. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6-to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 30-40 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Identification – INT-PWC-3

1. Coating Material:	Amine Cure Epoxy with Embedded Fiberglass Matt Reinforcement
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates Subject to Constant Immersion In Potable Water for Membrane Filtration Systems
4. Surface Preparations:	
a. General Considerations:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be

		removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP-6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all bugholes (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP4 in accordance with ICRI 310.2R prior to coating application.
	c. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5.	Field Application:	
	a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bugholes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch (125 mils) of thickness. Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
	b. Coating System Thickness:	100-125 mils dry film including Fiberglass Matt, in addition to the parge coat. System installation as per manufactures instructions as the systems application varies between manufacturers.
	c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
	d. Post Cure QC Testing:	Holiday Detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with ASTM D4787. Acceptance Criteria for Holiday Detection is no pinholes or holidays. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (Do mock-up of 200 square feet for verification purposes prior to commencing with production coating work),perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D7234. The target acceptance criteria are average of pull-off values of 250 psi, but actual acceptable value to be established by ASTM C1583 tests performed on substrate as required above. The coating system

	adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated, if that is greater. The acceptance criteria for coating pull-off adhesion testing shall also be failure plane percentage of minimum of 75% of failure plane on back of load fixture within the concrete substrate.
e. Pinhole, Holiday or Defect Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate. • Chip out and remove the concrete to expose the full dimensions in all 3 directions of the air void responsible for the defect. • Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6-to 8-mil profile in the intact coating system. • Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. • Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. • Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. • Apply the coating system in the number of coats necessary to achieve the specified 30-40 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-1

1. Coating Material:	Acrylic Elastomeric
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates Subject to Exterior Exposures and UV
4. Surface Preparations:	
a. General Considerations:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-1

b. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP-6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, repair all bugholes and voids that will be visible through the dried film using the specified filler surfacer. The filler surfacer shall be applied to a smooth transition to sound existing concrete with no obvious protruding edges. If the parge coat (filler/surfacer material is non-polymer modified), it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP2-3 in accordance with ICRI 310.2R prior to coating application.
c. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids. All bugholes and voids in the substrate shall be filled so they are not visible through the dried coating film. Note to Specifier: If the project is retrofit of existing structures and concrete restoration is deeper than 1/4 inch (covered by Filler/Surfacer Parge Coats), specify here the deeper restoration mortar from the CSM compatible with the coating system that can be used to restore concrete to depths up to 2 inches (between 1/4 inch and 2 inches). Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Prime Coat	1 Coat at 6-8 mils DFT.
c. Finish Coat	1 Coat at 6-8 mils DFT.
d. Coating System Thickness:	Total System 12-16 mils DFT.
e. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-1

f. Post Cure QC Testing:	Acceptance Criteria for Exterior Surfaces-Surfaces shall be free of bugholes and voids and the coating film will be applied in a continuous manner with full coverage over previous coats. The dried film will be free of runs, sags, drips, debris in film and excessive roller nap and brush strokes. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (DO MOCK-UP of 200 SF for verification purposes prior to commencing with production coating work). Perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated if that is greater.
g. Defect Repair Procedure:	Runs, Sags and Drips-Aggressively abrade, sand, or scrape to remove the defective coating in the area. Abrade the intact coating system surface at least 3 inches beyond the removal area in all directions to remove the produce a uniform profile in the intact coating system suitable to the directions provided on the CSM product data sheets. Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. Apply the coating system in the number of coats necessary to achieve the specified 50-60 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-2

1. Coating Material:	Acrylic
2. Surfaces:	Concrete
3. Service Conditions:	Concrete Substrates Subject to Exterior Exposures and UV
4. Surface Preparations:	
a. General Considerations:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-2

	adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. Alternatively, the prepared substrate can be thoroughly washed down with potable water to remove all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	New concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested as specified herein in 3.09. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting surface or ultrahigh pressure water jetting. Large voids or spalls and cracks shall be repaired as specified in the CSM's Crack Treatment Details. Surface Preparation must open up all shelled over air voids or bugholes to expose fully the void's depth, width, and length. Concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP-6 in accordance with ICRI 310.2R. Surface preparation must produce minimum concrete surface pH of 9.0. After surface preparation has been accepted, repair all bugholes and voids that will be visible through the dried film using the specified filler surfacer. The filler surfacer shall be applied to a smooth transition to sound existing concrete with no obvious protruding edges. If the parge coat (filler/surfacer material is non-polymer modified, it must be brush blast cleaned following adequate cure per CSM's instructions to produce a uniform anchor pattern of CSP 1-2 in accordance with ICRI 310.2R prior to coating application.
c. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes and voids. All bugholes and voids in the substrate shall be filled so they are not visible through the dried coating film. Note to Specifier: If the project is retrofit of existing structures and concrete restoration is deeper than 1/4 inch (covered by Filler/Surfacer Parge Coats), specify here the deeper restoration mortar from the CSM compatible with the coating system that can be used to restore concrete to depths up to 2 inches (between 1/4 inch and 2 inches). Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Prime Coat	1 coat at 1.5-2.0 mils DFT.
c. Finish Coat	1 coat at 1.5-2.0 mils DFT.
d. Coating System Thickness:	Total System Thickness 3.0-4.0 mils DFT.
e. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-PWC-2

f. Post Cure QC Testing:	Acceptance Criteria for Exterior Surfaces-Surfaces shall be free of bugholes and voids and the coating film will be applied in a continuous manner with full coverage over previous coats. The dried film will be free of runs, sags, drips, debris in film and excessive roller nap and brush strokes. Perform Adhesion Testing on concrete substrate after surface preparation prior to resurfacing mortar application in accordance with ASTM C1583. Perform at 10 representative locations (3 tests per location) to determine the tensile strength of the concrete substrate. Acceptance Criteria shall be minimum average target pull-off tensile strength of 250 psi. Based on the average ASTM C1583 test values, the acceptance criteria for tensile pull-off strength for coating adhesion can be established. When coating system mock-up application has been performed (Do mock-up of 200 square feet for verification purposes prior to commencing with production coating work), perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated if that is greater.
g. Defect Repair Procedure:	Runs, Sags and Drips-Aggressively abrade, sand, or scrape to remove the defective coating in the area. Abrade the intact coating system surface at least 3 inches beyond the removal area in all directions to remove the produce a uniform profile in the intact coating system suitable to the directions provided on the CSM product data sheets. Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. Apply the coating system in the number of coats necessary to achieve the specified 3.0-4.0 mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCC-1

1. Coating Material:	Acrylic Elastomeric
2. Surfaces:	Previously Painted/Coated Concrete
3. Service Conditions:	Concrete Substrates Subject to Exterior Exposures and UV
4. Surface Preparations:	
a. General Preparations:	Prior to proceeding with coating applications, it is imperative to perform adhesion testing and compatibility testing on the existing coating to assess the existing condition of the surface. Perform adhesion testing of coating system of the existing coating in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. Adhesion testing should be performed on a representative area of each surface to be coated (roof, walls etc.). All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be

	submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party. The surface shall be prepared using Low Pressure Water Cleaning (LPWC) with a minimum pressure of 3,500 psi using a spin jet nozzle. Wet abrasive/Vapor Blasting or water jetting surface preparation methods can be used if deemed necessary for certain aspects of the project. The concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) until suitable substrate conditions exist as per the CSM's Technical Data Sheets for the application of primers or coatings. The exception to this is when filler/surfacers or mortars require pre-wetted substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. The prepared substrate shall be free of all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	Only tightly adherent existing material is allowed to remain on the surface after surface preparation. Tightly adherent coatings shall be identified by using the "Dull Putty Knife" Method. Areas where existing coating has been removed, either to bare concrete or to a previous tightly adherent layer shall have all edges feathered using the appropriate grit of sandpaper to create a gradual and smooth transition to the next layer. Special attention shall be given to ensure all edges of existing coating are tightly adhered and locked down. Edges that show lifting after the application of primers, intermediate or finish coats shall be further prepared to eliminate all chances of lifting or peeling. After surface preparation has been accepted, repair all bugholes and voids that will be visible through the dried film using the specified filler surfacer. The filler surfacer shall be applied to a smooth transition to sound existing concrete with no obvious protruding edges. Large cracks (>1/8 inch) shall be filled using the specified cementitious or epoxy-based filler material as per the CSM's instructions. The filler material shall be sufficiently dried as per the CSM's instructions prior to application of primer. Cracks <1/8 inch can be filled using a polyurethane sealant provided by the CSM. The Polyurethane Sealant shall be installed in a neat manner and struck flush with the surface. Surface preparation must produce minimum concrete surface pH of 9.0 on any bare concrete exposed during surface preparation. Bare concrete shall have a minimum surface profile of CSP 1-2 in accordance with ICRI 310.2R prior to coating application. After cleaning, concrete surfaces shall be sealed with the specified primer.
c. Masonry:	Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure sufficiently as per CSM's instructions before the application of primers or coatings. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, bare masonry surfaces shall be sealed with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes, voids and cracks. All bugholes and voids in the substrate shall be filled so they are not visible through the dried coating film.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCC-1

	Drying time between coats shall be as specified by the CSM for the site conditions.
b. Coating System Thickness:	Spot Prime all bare concrete and masonry surfaces to a DFT of 2-3 mils. Minimum 2 finish coats at 6-8 mils per coat dry film in addition to the primer and filler material.
c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
d. Post Cure QC Testing:	Acceptance Criteria for Exterior Surfaces-Surfaces shall be free of bugholes and voids and the coating film will be applied in a continuous manner with full coverage over previous coats. The dried film will be free of runs, sags, drips, debris in film and excessive roller nap and brush strokes. When coating system mock-up application has been performed (DO MOCK-UP of 200 SF for verification purposes prior to commencing with production coating work), perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated if that is greater.
e. Defect Repair Procedure:	Runs, Sags and Drips-Aggressively abrade, sand, or scrape to remove the defective coating in the area. Abrade the intact coating system surface at least 3-inches beyond the removal area in all directions to remove the produce a uniform profile in the intact coating system suitable to the directions provided on the CSM product data sheets. Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. Apply the coating system in the number of coats necessary to achieve the specified mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Coating System Specification Sheets (COATSPEC)

Coating System Identification – EXT-OCC-2

1. Coating Material:	Acrylic
2. Surfaces:	Previously Painted/Coated Concrete
3. Service Conditions:	Concrete Substrates Subject to Exterior Exposures and UV
4. Surface Preparations:	
a. General Considerations:	Prior to proceeding with coating applications, it is imperative to perform adhesion testing and compatibility testing on the existing coating to assess the existing condition of the surface. Perform Adhesion Testing of coating system of the existing coating in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. Adhesion testing should be performed on a representative area of each surface to be coated (roof, walls etc.). All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to

	produce one at no additional cost to the Owner, the Engineer, or any other party. The surface shall be prepared using Low Pressure Water Cleaning (LPWC) with a minimum pressure of 3,500 psi using a spin jet nozzle. Wet abrasive/Vapor Blasting or water jetting surface preparation methods can be used if deemed necessary for certain aspects of the project. The concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) until suitable substrate conditions exist as per the CSM's Technical Data Sheets for the application of primers or coatings. The exception to this is when filler/surfacers or mortars require pre-wetted (SSD) substrates to assure proper adhesion. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials. The prepared substrate shall be free of all loose debris, dust, and other materials leaving a clean sound substrate that is dust-free.
b. Concrete:	Only tightly adherent existing material is allowed to remain on the surface after surface preparation. Tightly adherent coatings shall be identified by using the "Dull Putty Knife" Method. Areas where existing coating has been removed, either to bare concrete or to a previous tightly adherent layer shall have all edges feathered using the appropriate grit of sandpaper to create a gradual and smooth transition to the next layer. Special attention shall be given to ensure all edges of existing coating are tightly adhered and locked down. Edges that show lifting after the application of primers, intermediate or finish coats shall be further prepared to eliminate all chances of lifting or peeling. After surface preparation has been accepted, repair all bugholes and voids that will be visible through the dried film using the specified filler surfacer. The filler surfacer shall be applied to a smooth transition to sound existing concrete with no obvious protruding edges. Large cracks (>1/8 inch) shall be filled using the specified cementitious or epoxy-based filler material as per the CSM's instructions. The filler material shall be sufficiently dried as per the CSM's instructions prior to application of primer. Cracks <1/8 inch can be filled using a polyurethane sealant provided by the CSM. The Polyurethane Sealant shall be installed in a neat manner and struck flush with the surface. Surface preparation must produce minimum concrete surface pH of 9.0 on any bare concrete exposed during surface preparation. Bare concrete shall have a minimum surface profile of CSP 1-2 in accordance with ICRI 310.2R prior to coating application. After cleaning, concrete surfaces shall be sealed with the specified primer.
c. Masonry:	Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure sufficiently as per CSM's instructions before the application of primers or coatings. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be tested for moisture content in accordance with the CSM's recommendations. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, bare masonry surfaces shall be sealed with the specified primer.
5. Field Application:	
a. General:	Surfacer or filler shall be applied per CSM's recommendations prior to application of coating to fill all bugholes, voids and cracks. All bugholes and voids in the substrate shall be filled so they are not visible through the dried coating film. Drying time between coats shall be as specified by the CSM for the site conditions.

Coating System Specification Sheets (COATSPEC)	
Coating System Identification – EXT-OCC-2	
b. Coating System Thickness:	Spot Prime all bare concrete & masonry surfaces to a DFT of 1.5 -2 mils. 2 finish coats may be required at 1.5-2.0 mils per coat dry film in addition to the primer and filler material to achieve uniform coverage.
c. Routine QC Inspection Tasks:	Refer to Tables in 3.09 of this Section.
d. Post Cure QC Testing:	Acceptance Criteria for Exterior Surfaces-Surfaces shall be free of bugholes and voids and the coating film will be applied in a continuous manner with full coverage over previous coats. The dried film will be free of runs, sags, drips, debris in film and excessive roller nap and brush strokes. When coating system mock-up application has been performed (DO MOCK-UP of 200 SF for verification purposes prior to commencing with production coating work). Perform Adhesion Testing of coating system on mock-up area (6 tests total) in accordance with ASTM D3359 Method A-X Cut. The target acceptance criteria are an average of 4A or better. The coating system adhesion tests shall be performed at least at one location for every 1,000 SF of area to be coated and be performed at areas representative of the entire area to be coated if that is greater.
e. Defect Repair Procedure:	Runs, Sags and Drips-Aggressively abrade, sand, or scrape to remove the defective coating in the area. Abrade the intact coating system surface at least 3 inches beyond the removal area in all directions to remove the produce a uniform profile in the intact coating system suitable to the directions provided on the CSM product data sheets. Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area. Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations. Apply the coating system in the number of coats necessary to achieve the specified mils DFT over the defect and coating removal areas and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

3.08 FINISH SCHEDULE

A. Refer to 09 90 00 for the Finish Schedule.

3.09 ROUTINE QUALITY CONTROL INSPECTION/TESTING REQUIREMENTS

A. The routine QC inspection tasks and tests listed below are required for all standard High Performance Coating Systems covered in this Section. All findings to be compared for compliance with this Section and the referenced product data sheets from the CSM. All of the QC tasks/tests listed below are to be included in the Contractor's QC Testing and Inspection Plan as required in this Section and documented on Form 09 97 00 A and/or 09 97 00 B. The frequency of any test or inspection task may need to be adjusted based upon consistent or inconsistent quality results. Key tests/verifications are that required for 100% all surfaces. Measurement/testing should be adjusted as required to confirm 100% of the coating is in compliance with the requirements.

Routine Quality Control Inspection/Testing Requirements Table

Inspection Task or Test	Referenced Standard or Practice	Acceptance Criteria	Frequency of Test or Inspection Task
Inspect compressed air to be free of oil and moisture.	ASTM D4285	Free of Oil and Moisture	Every 2 hours per shift worked.
Check pressure gauge for water jetting or test pressure for abrasive blast cleaning compressed air.	Needle Gage No Standard	As Specified	Every 4 hours per shift worked.
Measure ambient air and substrate temperature.	Electronic Hygrometer Positector or Elcometer DPM	As per CSM Product data Sheets	Every 2 hours per shift worked.
Measure relative humidity and dew point of air in coating area.	Electronic Hygrometer Positector or Elcometer DPM	Surface Temperature 5°F above the Dew Point and Stabilized	Every 2 hours per shift worked.
Test concrete substrate for moisture.	Phase 1- ASTM D4263 (Qualitative) Phase 2 (If Moisture Present) – ASTM F1869 or ASTM F2170	ASTM F1869-<3lbs per 1000 Sq Ft/24 Hrs ASTM F2170 70% RH or less	Twice per shift worked and prior to coating application.
Inspect steel or other ferrous metals for Degree of Cleanliness in Carbon Steels.	SSPC VIS-1 (ASTM D2200) SSPC VIS-3 SSPC VIS-4 SSPC VIS-5	As per the Specification	All surfaces checked prior to coating – 100% surface in compliance as per SSPC SP standards
Cast and Ductile Iron Degree of Cleanliness.	NAPF 500-03 NAPF 500-03-04 NAPF 500-03-05	As per the Specification	All surfaces checked prior to coating – 100% surface in compliance as per SSPC SP standards
Inspect steel or other ferrous Metals for degree of dust left on the surface.	ISO 8502-3	Dust Rating 1 Dust Particle Size 0	100% of all surfaces checked prior to coating.
Metal Surface Profile of Steel – Abrasive Blast cleaned.	ASTM D4417 Method A or C (Same for ductile and cast iron and stainless steel)	As per the Specification	100% surface in compliance with manufacturers surface profile requirements
Inspect Concrete Surface Profile by Comparison to Replicas.	ICRI 310.2R	As per the Specification	100% surface in compliance with manufacturers surface profile requirements.
Inspect Concrete for Soundness with Hammer Testing	N/A	No Hollow Concrete Areas	Check for soundness visually 100% and hammer test every 10 sq ft or where cracked or loose concrete is apparent visually.
Inspect Surface pH of Prepared Concrete.	ASTM D4262	Min 9 pH	Every 100 sq. ft to be coated.
Calculate Coverage of Filler/Surfacers or Mortars based on CSM's Coverage Robes and Measure Thickness with Needle or Calibrated Wire.	N/A	As per Specification	For all surfaces to be surfaced and filled with parge coat of mortar.
Measure WFT of Coatings Over Metal.	ASTM D4414	As per CSM Product Data Sheets	Every 10 sq ft to be coated.
Measure WFT of Coatings Over Parge Coats – Troweled Over	ASTM D4414	As per CSM Product Data Sheets	Every 10 sq ft to be coated.

Routine Quality Control Inspection/Testing Requirements Table

Inspection Task or Test	Referenced Standard or Practice	Acceptance Criteria	Frequency of Test or Inspection Task
Concrete or Masonry.			
Visually Inspect All Coating Film for Film Quality e.g. Pinholes, Holidays, Runs, Sags, etc.	N/A	Pinhole Free surface and free of runs and sags	100% of all surfaces to be coated.
Measure DFT of Coatings on Ferrous Metals.	SSPC PA2 Level 3	As Specified	As prescribed by SSPC PA2
Measure DFT of Coatings on Concrete Substrates.	SSPC PA9 Level 3	As Specified	As prescribed by SSPC PA9
Discontinuity Testing (Holiday Detection) on Metal Surfaces.	ASTM D5162 >- 20 mils Method B < - 20mils Method A	Pinhole Free Surface	Addressed in Applicable COATSPECS
Discontinuity Testing (Holiday Detection) on Concrete Substrates.	ASTM D4787	Pinhole Free Surface	Addressed in Applicable COATSPECS
Adhesion Testing on Metallic Substrates.	ASTM D4541	800 psi Min	Addressed in Applicable COATSPECS
Adhesion Testing on Concrete Substrates.	ASTM C4583 ASTM D7234	250 Psi Min	Addressed in Applicable COATSPECS
Reinspect for Rework from all Non-Compliant Issues Identified from QC Inspection listed above.	N/A	Meets all Specified standards	As needed.

3.10 OPTIONAL OWNER QUALITY ASSURANCE REVIEW

A. General:
   1. Inspection by the Owner or others does not limit the Contractor's or CSA's responsibilities for quality workmanship or sole responsibility for QC as specified by this Section or as required by the CSM's instructions. Inspection by the Owner is optional and is additional to any inspection required to be performed by the Contractor.
   2. The Owner may perform, or contract with an inspection agency to perform, QA inspection and testing of the coating work covered by this Section. These inspections may include the following:
      a. Inspect materials upon receipt to ensure that all are supplied by the same CSM.
      b. Inspect to verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
      c. Inspect and record findings for the degree of cleanliness of substrates.
      d. Inspect and record the pH of concrete and metal substrates.
      e. Inspect and record substrate profile (anchor pattern).
      f. Measure and record ambient air and substrate temperature.
      g. Measure and record relative humidity.
      h. Check for the presence of substrate moisture in the concrete.

i. Inspect to verify that correct mixing of coating system materials is performed in accordance with CSM's instructions.

j. Inspect, confirm, and record that the "pot life" of coating system materials is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.

k. Perform adhesion testing.

l. Measure and record the thickness of the coating system.

m. Inspect to verify proper curing of the coating system in accordance with the CSM's instructions.

n. Limited visual observations for defects.

3.11 FINAL INSPECTION

A. General

1. Contractor shall conduct a final inspection to determine whether coating system work meets the requirements of the specifications.
2. The Construction Manager or Owner's Representative will subsequently conduct a final observation with the Contractor to observe the completed work.
3. Any obvious defects or non-conforming work shall be marked. Such areas shall be recleaned and repaired as specified at no additional cost to the Owner.

09 97 00-A STEEL PW COATING SYSTEM QUALITY CONTROL CHECKLIST

Project Name

Owner		**Coating System Manufacturer Technical CTR**	
General Contractor (GC)		**Coating System Applicator (CSA)**	
Area or Structure		**Location within Structure**	
Coating System (e.g., INT PWS#1)		**Coating Type (e.g., Epoxy, etc.)**	

Coating System Quality Control Checklist

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
1	Completion of pre-cleaning and substrate decontamination prior to abrasive blast cleaning	Surface free of all oil, grease and all other foreign contaminants.				
2	Soluble Chloride Testing	Max 30 micro siemens as per ISO 8502-6/8502-9	GC QC			
			CTR QC			
			CSA QC			
3	Ensuring compressed air for abrasive blasting or coating/lining application is free of oil and moisture	ASTM D4285- Free of all oil & moisture	GC QC			
		1 blotter test per 2 hours of compressed air usage	CTR QC			
			CSA QC			
4	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	Conforms to SSPC Guide 6 Guidelines and specification requirements.	GC QC			
			CTR QC			
			CSA QC			
5	Completion of ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	Substrate minimum of 5 degrees above the dew point and stabilized.	GC QC			
		Recording ambient conditions, a minimum of 4 times per shift/day at 2-hour intervals	CTR QC			
		Negative pressure of enclosure. Visual inspection of enclosure tarps indicating negative pressure.	CSA QC			
6	Check pressure gauge for water jetting or test pressure for	As Specified	GC QC			
			CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	abrasive blast cleaning compressed air.		CSA QC			
7	Interior Tank Steel - Completion of Surface Preparation for Interior lining applications.	SSPC-SP10/NACE#2 (CS)	GC QC			
		NAPF 500-03 (04&05)	CTR QC			
		ASTM D4417 Method C- Surface Profile ?_mils	CSA QC			
8	Steel- Dust Level Testing- After surface preparation and prior to application of primers/coatings	ISO 8502-3 (Part 3)	GC QC			
		Dust Rating-1	CTR QC			
		Dust Particle Size - 0	CSA QC			
9	Exterior Tanks Steel - Completion of Surface Preparation for Exterior Coating applications.	SSPC-SP6/NACE#3 (CS)	GC QC			
		NAPF 500-03 (04&05)	CTR QC			
		ASTM D4417 Method C- Surface Profile ?_mils	CSA QC			
10	Steel- Dust Level Testing- After surface preparation and prior to application of primers/coatings	ISO 8502-3 (Part 3)	GC QC			
		Dust Rating - 1	CTR QC			
		Dust Particle Size - 0	CSA QC			
11	Interior Tank Steel- Completion of primer/1st coat application (only required if using a primer or for multiple coat applications)	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
12	Exterior Tank Steel- Completion of primer/1st coat application.	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
13	Exterior Tank Steel- Completion of Intermediate Coat /2nd coat application	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
14	Exterior Tank Steel- Completion of Finish Coat application	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
15	Interior Tank Steel- Completion of Pit Filling of Steel Surfaces	All required pits filled	GC QC			
		Filler Truck Off Flush with Steel	CTR QC			
			CSA QC			
16	Interior Tank Steel - Completion of Stripe Coat (Epoxy)	All Leading/Sharp Edges	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
17	Interior Tank Steel- Completion of Lining Coat	DFT meets specifications as per SSPC PA2	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
18	Completion of Full and Proper Cure of Lining System.	ASTM D5402- No material transfer	GC QC			
		ASTM D2240- Shore D- Must match value stated on CTR PDS data.	CTR QC			
			CSA QC			
19	Interior Steel - Completion of Testing of Cured coating System including Adhesion, Holiday (Continuity) Testing.	ASTM D5162- Pinhole/holiday free	GC QC			
		ASTM D4541- min 800 psi	CTR QC			
			CSA QC			
20	Steel- Completion of Localized Repairs to Coating System Following Testing.	ASTM D5162- Pinhole/holiday free	GC QC			
		Visual inspection for film quality- no runs, sags or other defects	CTR QC			
			CSA QC			
21	Final Acceptance of Coating/Lining System Installation Including Final Clean-Up Complying with Specification Requirements and the CTR's Quality Requirements.	Coatings/linings meet all specification requirements	GC QC			
			CTR QC			
			CSA QC			

09 97 00-B CONCRETE PW COATING SYSTEM QUALITY CONTROL CHECKLIST

Project Name

Owner		**Coating System Manufacturer Technical CTR**	
General Contractor (GC)		**Coating System Applicator (CSA)**	
Area or Structure		**Location within Structure**	
Coating System (e.g., INT PWC#1)		**Coating Type (e.g., Epoxy, etc.)**	

Coating System Quality Control Checklist

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
1	Completion of pre-cleaning and substrate decontamination prior to abrasive blast cleaning.	Surface free of all oil, grease, form release agents and all other foreign contaminants	GC QC			
		Host Substrate Min pH9	CTR QC			
		ASTM F22- No Moisture Lens Formation	CSA QC			
2	Moisture Testing	Step 1- Initial Testing as Per ASTM D4263- if moisture present move to step 2 or 3	GC QC			
		Step 2- ASTM F1869- < 3lbs/1000 sq. ft/24 hours	CTR QC			
		Step 2 Alternate- ASTM F2170- Substrate RH 70% or less.	CSA QC			
3	Ensuring compressed air for abrasive blasting or coating/lining application is free of oil and moisture	ASTM D4285- Free of all oil & moisture	GC QC			
		1 blotter test per 2 hours of compressed air usage	CTR QC			
			CSA QC			
4	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	Conforms to SSPC Guide 6 Guidelines and specification requirements.	GC QC			
			CTR QC			
			CSA QC			
5	Completion of ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	Substrate minimum of 5 degrees above the dew point and stabilized.	GC QC			
		Recording ambient conditions, a minimum of 4 times per	CTR QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
		shift/day at 2-hour intervals				
		Negative pressure of enclosure. Visual inspection of enclosure tarps indicating negative pressure.	CSA QC			
6	Check pressure gauge for water jetting or test pressure for abrasive blast cleaning compressed air.	As specified	GC QC			
			CTR QC			
			CSA QC			
7	Completion of Surface Preparation for concrete deep repair applications. (If required)	SSPC SP CAB 1 and SSPC-SP13/NACE #6	GC QC			
		Surface Profile- ICRI CSP#5 minimum	CTR QC			
			CSA QC			
8	Completion of Concrete Deep Repairs (If required) and Related Surface Preparation Rework Prior to Concrete Filler/Re-surfacer/Parge.	SSD Maintained throughout application	GC QC			
		SSPC SP CAB 1 and SSPC-SP13/NACE #6	CTR QC			
		Surface Profile- ICRI CSP#5 minimum	CSA QC			
9	Adhesion testing of host concrete as per ASTM C1583. Conduct tests in 3 representative locations. 3 tests per location. Glue failures are not considered a completed test.	Report all adhesion values measured	GC QC			
		Report average results of test areas.	CTR QC			
			CSA QC			
10	Completion of Concrete Filler/Re-surfacer/Parge Coat Application to Concrete Prior to Coating System Application.	SSD Maintained throughout application	GC QC			
		Visual inspection of uniformity of fill and dispersal	CTR QC			
			CSA QC			
11	Concrete - Completion of Surface Preparation for coating & lining applications.	SSPC SP CAB 1 and SSPC-SP13/NACE #6	GC QC			
		Surface Profile- ICRI CSP#4 minimum	CTR QC			
			CSA QC			
12	Concrete- Adhesion testing on installed repair mortar (after min 72 hour cure) as per ASTM C1583. Conduct tests in 3	Minimum 250 psi	GC QC			
		75% minimum host concrete failure	CTR QC			
			CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	representative locations. 3 tests per location. Glue failures are not considered a completed test.					
13	Concrete- Completion of Primer Application. (If required)	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
14	Concrete- Completion of Intermediate Coat Application and of Detail Treatment at Transitions or Terminations. (Only applicable in 2 coat applications)	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
15	Concrete - Completion of Finish Coat Application and of Detail Treatment at Transitions and Terminations.	DFT meets specifications as per SSPC PA9	GC QC			
		Visual Inspection- Film free of coating defects, pinholes and debris.	CTR QC			
			CSA QC			
16	Completion of Full and Proper Cure of Lining System.	ASTM D5402- No material transfer	GC QC			
		ASTM D2240- Shore D- Must match value stated on CTR PDS data.	CTR QC			
			CSA QC			
17	Concrete - Completion of Testing of Cured Lining System including Adhesion, Holiday (Continuity) Testing.	ASTM D4787- Pinhole/holiday free	GC QC			
		ASTM D7234- TBD by results of ASTM C1583 testing of host concrete and repair mortar	CTR QC			
			CSA QC			
18	Concrete- Completion of Localized Repairs to Lining System Following Testing.	ASTM D4787- Pinhole/holiday free	GC QC			
		Visual inspection for film quality- no runs, sags or other defects	CTR QC			
			CSA QC			
19	Final Acceptance of Coating/Lining System Installation Including Final Clean-Up Complying with Specification Requirements	Coatings/linings meet all specification requirements	GC QC			
			CTR QC			
			CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
	and the CTR's Quality Requirements.					

END OF SECTION

SECTION 10 14 00

SIGNAGE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies informational and accident prevention signs.

1.02 OPERATING AND DESIGN REQUIREMENTS

A. General:
   1. Accident prevention signs shall conform as to design with OSHA Section 1910.145 of Subpart J, Part 1910, Chapter XVII, Title 29 of the Code of Federal Regulations. Exit signs shall conform with Section 1910.37(g) of the OSHA Safety and Health Standard for General Industry, Article 10, Section 10.113 of the Uniform Fire Code, and where applicable with local fire regulations.
   2. In addition to the signs identified on the schedule in Part 3 of this section, the following shall be provided:
      a. Exit signs shall be provided in accordance with Section 26 50 00.
      b. "Caution Automatic Equipment May Start at Any Time" signs shall be provided in accordance with paragraph 43 05 11-2.07.

B. Design Requirements:
   1. Size:
      a. Sign size shall be as follows:
         1) 14 inch x 20 inch
         2) 10 inch x 14 inch
         3) 7 inch x 10 inch
   2. Type:
      a. The sign type shall be as follows:

Type	Message
[	
	]

PART 2 PRODUCTS

2.01 GENERAL

A. Sign lettering shall be single stroke and shall contrast in color with the background. For those messages for which there are international symbols, the international symbols shall be used. Chain mounted signs shall have lettering on both sides.

2.02 MATERIALS

A. Signs shall be 0.100-inch thick fiberglass with embedded fadeproof legends.

PART 3 EXECUTION

3.01 GENERAL

A. Signs shall be distributed as follows:

Location	Number	Size	Message	Mount
[				
				]

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. Underlavatory guards.
   3. Custodial accessories.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated Design Submittal: For grab bars.
   1. Include structural design calculations indicating compliance with specified structural-performance requirements.

1.03 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Warranties.

1.05 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. Warranty Period: 10 years from date of Substantial Completion.

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. Structural Performance: Design accessories and fasteners to comply with the following requirements:
   1. Grab Bars: Installed units are able to resist 250 lbf concentrated load applied in any direction and at any point.

C. 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. Or approved equal.

2.02 PUBLIC-USE WASHROOM ACCESSORIES

A. Toilet Tissue (Roll) Dispenser:
   1. Description: Double-roll dispenser.
   2. Mounting: Surface mounted.
   3. Operation: Non-control delivery with standard spindle.
   4. Capacity: Designed for 4-1/2- or 5-inch- diameter tissue rolls.
   5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

B. Combination Towel (Folded) Dispenser/Waste Receptacle:
   1. Description: Combination unit for dispensing C-fold or multifold towels, with removable waste receptacle.
   2. Mounting: Surface mounted.
   3. Minimum Towel-Dispenser Capacity: 600 C-fold or 800 multifold paper towels.
   4. Minimum Waste-Receptacle Capacity: 4 gal.
   5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
   6. Liner: Reusable, vinyl waste-receptacle liner.
   7. Lockset: Tumbler type for towel-dispenser compartment.

C. Soap Dispenser:
   1. Description: Designed for manual operation and dispensing soap in liquid or lotion form.
   2. Mounting: Vertically oriented, surface mounted.
   3. Lockset: Tumbler type.
   4. Refill Indicator: Window type.

D. Grab Bar:
   1. Mounting: Flanges with concealed fasteners.
   2. Material: Stainless steel, 0.05 inch thick.
      a. Finish: Smooth, ASTM A480/A480M No. 4 finish (satin).
   3. Outside Diameter: 1-1/2 inches.
   4. Configuration and Length: As indicated on Drawings.

E. Mirror Unit:
   1. Frame: Stainless steel angle, 0.05 inch thick.
      a. Corners: Welded and ground smooth.
   2. Size: As indicated on Drawings.
   3. Shelf:
      a. Type: Integral, welded.
      b. Depth: 5 inches.
   4. Hangers: Manufacturer's standard rigid, tamper and theft resistant.

F. Hook:
   1. Description: Double-prong unit.
   2. Mounting: Exposed.
   3. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

2.03 UNDERLAVATORY GUARDS

A. Under-lavatory Guard:
   1. Description: Insulating pipe covering for supply and drain piping assemblies that prevents direct contact with and burns from piping; allow service access without removing coverings.
   2. Material and Finish: Antimicrobial, molded plastic, white.

2.04 CUSTODIAL ACCESSORIES

A. Custodial Mop and Broom Holder:
   1. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
   2. Length: 36 inches.
   3. Hooks: Four.
   4. Mop/Broom Holders: Three, spring-loaded, rubber hat, cam type.
   5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
      a. Shelf: Not less than nominal 0.05-inch-thick stainless steel.
      b. Rod: Approximately 1/4-inch-diameter stainless steel.

2.05 FABRICATION

A. 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.

B. Grab Bars: Install to comply with specified structural-performance requirements.

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.

1.03 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. 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.

2.02 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each 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. Amerex Corporation.
      b. Ansul; brand of Johnson Controls International plc, Building Solutions North America.
      c. Babcock-Davis.
      d. Badger Fire Protection; a Carrier company.
      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. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B.

B. Multipurpose Dry-Chemical Type: UL-rated 4A:80B:C, 10 lb. nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled 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.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Architect.
   1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.
      a. Orientation: Vertical.

PART 3 EXECUTION

3.01 INSTALLATION

A. Examine fire extinguishers for proper charging and tagging.
   1. Remove and replace damaged, defective, or undercharged fire extinguishers.

B. Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

C. 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 above finished floor.

END OF SECTION

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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.

B. Shop Drawings: For metal lockers.
   1. Include plans, elevations, sections, and attachment details.
   2. Include locker identification system and numbering sequence.

C. Samples: For each color specified.

1.03 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.05 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. Warranty Period for Welded Metal Lockers: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 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. ASI Storage Solutions.
   2. Lyon LLC.
   3. Olympus Lockers & Storage Products, Inc.
   4. Penco Products, Inc.
   5. Republic Storage Systems, LLC.

B. Doors: One piece; fabricated from 0.075-inch 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 wide; welded to inner face of doors.
   2. Door Style: Vented panel as follows:

      a. Louvered Vents: No fewer than three louver openings at top and bottom for double-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 nominal thickness.
   2. Backs: 0.048-inch nominal thickness.
   3. Shelves: 0.060-inch nominal thickness, with double bend at front and single bend at sides and back.

D. Frames: Channel formed; fabricated from 0.060-inch 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.

E. Hinges:
   1. Knuckle Hinges: Steel, full loop, five or seven knuckles, tight pin; minimum 2 inches high. Provide no fewer than three hinges for each door more than 42 inches high.
   2. Continuous Hinges: Manufacturer's standard, steel, full height.
   3. 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. Multipoint Latching: Finger-lift latch control designed for use with built-in combination locks or padlocks; positive automatic latching and prelocking.

      b. Latch Hooks: Equip doors 48 inches and higher with three latch hooks and doors less than 48 inches high with two latch hooks; fabricated from 0.120-inch nominal-thickness steel sheet; welded to full-height door strikes; with resilient silencer on each latch hook.

      c. Latching Mechanism: Manufacturer's standard, rattle-free latching mechanism.

G. Identification Plates: Manufacturer's standard, etched, embossed, or stamped aluminum plates, with numbers and letters at least 3/8 inch high.

H. Hooks: Manufacturer's standard ball-pointed, aluminum or steel; zinc plated.

I. Coat Rods: Manufacturer's standard.

J. Continuous Zee Base: Fabricated from, manufacturer's standard thickness, but not less than 0.060-inch nominal-thickness steel sheet.
   1. Height: 4 inches.

K. Continuous Sloping Tops: Fabricated from 0.048-inch nominal-thickness steel sheet, with a pitch of approximately 20 degrees.
   1. Closures: Vertical-end type.

L. Filler Panels: Fabricated from 0.048-inch nominal-thickness steel sheet.

M. Finished End Panels: Fabricated from 0.024-inch nominal-thickness steel sheet to cover unused penetrations and fasteners, except for perimeter fasteners, at exposed ends of nonrecessed metal lockers; finished to match lockers.

N. 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 A60 zinc-iron, alloy (galvannealed) coating designation.

O. Finish: Baked enamel or powder coat.
   1. Color: As selected by Architect from manufacturer's full range.

2.02 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.

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. Double-Tier Units: 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. Continuous Zee Base: Fabricated in lengths as long as practical to enclose base and base ends; finished to match lockers.

F. Continuous Sloping Tops: Fabricated in lengths as long as practical, without visible fasteners at splice locations; finished to match lockers.

G. Filler Panels: Fabricated in an unequal leg angle shape; finished to match lockers. Provide slip-joint filler angle formed to receive filler panel.

H. Finished End Panels: Fabricated to conceal unused penetrations and fasteners, except for perimeter fasteners, at exposed ends of nonrecessed metal lockers; finished to match lockers.

PART 3 EXECUTION

3.01 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 o.c. Using concealed fasteners, install anchors through backup reinforcing plates, channels, or blocking as required to prevent metal distortion.
   2. Anchor single rows of metal lockers to walls near top and bottom of lockers.

B. Welded Lockers: Connect groups together with manufacturer's standard fasteners, with no exposed fasteners on face frames.

C. 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.
   3. Attach sloping-top units to metal lockers, with closures at exposed ends.
   4. Attach finished end panels using fasteners only at perimeter to conceal exposed ends of nonrecessed metal lockers.

END OF SECTION

SECTION 13 33 13

GEODESIC DOMES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies design, fabrication, and erection of aluminum geodesic dome covers on clarifier, connections, sealing system to existing wall, access and associated details to support ducts and other equipment illustrated on the Drawings.

B. Type:

1. The covers shall be all aluminum, fully triangulated space trusses with noncorrugated closure panels, and shall be substantially air-tight as noted below. Covers shall be clear-span domes designed to be self-supported with integral tension and compression rings. The integral tension ring at the perimeter of the cover shall resist all gravity lateral loads and ensure that only vertical gravity reactions are transmitted to the structure. Wind and seismic lateral forces may be transmitted primarily as shear, along with vertical component from overturning and/or wind uplift. Loads may only be transmitted to the existing structure at the top of tank walls as shown on the Drawings.
2. The aluminum closure panels shall be attached continuously along their edges to the structural members by batten bars which engage the panels in an interlocking joint. The batten bars shall also secure a gasket along the panel edge to form a continuous water-tight surface over the entire dome structure. The use of panel attachment fasteners which penetrate both the panel and the flange of the structural member is expressly prohibited. The dome covers shall be provided with a substantially airtight membrane seal between the tank wall and the cover panels.

C. Unit Responsibility

1. The responsible manufacturer shall coordinate selection and design of all system components, and either install same or approve installer, such that all equipment furnished under the specification for the geodesic dome system, including items specified elsewhere but referenced in the specification, are compatible and operate properly to achieve the performance requirements specified. Agents, representatives or other entities who are not a direct component of the manufacturing corporation will not be acceptable as a substitute for the manufacturer's corporation in meeting this requirement. This requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems.
2. The Contractor shall assure that all geodesic dome systems provided for the project are products for which unit responsibility has been accepted by the responsible manufacturer. Unit Responsibility Certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

D. Performance and Design Requirements

1. Dimensions:

a. Tank covers shall be provided in accordance with the following dimensions:

1)	Tank inside diameter	58'-0" *
2)	Cover outside diameter of flashing	TBD *
3)	Cover center height above base of cover	TBD

[- Field verify against existing structure prior to submission of shop drawings.]*

2. Structural Requirements

a. Each cover shall be designed for full dead-load of cover and attached mechanical equipment, ducts and electrical items, plus the following live-load conditions:

1) Symmetrical downward (gravity) snow loading over the total area. See General Structural Notes in the Drawings.

a)	Ground Snow Load	70 psf
b)	Snow Exposure Factor, Ce	1.0
c)	Importance Factor, Is	1.2
d)	Thermal Factor, Ct	1.2
e)	Slope Factor, Cs	1.0
f)	FM Global Ground to Roof Snow factor	0.8

2) Snow drift per ASCE 7 as required.

3) Symmetrical outward HVAC overpressure of 5 pounds per square foot over the total area, netted against the full dead load of the cover.

4) Asymmetrical downward (gravity) live roof loading of 20 pounds per square foot over the projected area of one-half of the cover, but not to be combined with snow loading.

5) Wind loading (See General Structural Notes)

a)	Basic Design Wind Speed, V	120 mph
b)	Velocity pressure exponent coefficient, Kd	0.85
c)	Ground elevation factor, Ke	0.85
d)	Exposure category	C
e)	Internal Pressure Coefficient, GCpi	0.18
f)	Topographic Factor, Kzt	1.0

6) Seismic loading as described in Specification Section 01 73 24.

7) Each aluminum panel shall be secured to the dome frame and capable of withstanding two concentrated loads of 250 pounds each, applied simultaneously on two separate one square foot areas of the panel or 60 psf distributed over the total panel area

8) The full wind load (Item 5) in combination with the asymmetrical load (Item 4) acting on the leeward half of the cover.

9) The full seismic load (Item 6) in combination with the asymmetrical load (Item 4).

10) Full provisions shall be made to allow for thermal expansion and contraction.

b. The above conditions shall be otherwise combined per IBC 2021 load combinations.

3. Design Standards
    a. Aluminum covers shall be designed in compliance with the IBC and Aluminum Association including all associated standards, references and specifications.

E. Sealing:
    1. The perimeter, access hatch, manway door and all panels of each dome cover shall be sealed to the clarifier walls or to other dome components to provide a substantially air tight enclosure. The cover seal at wall shall be as detailed on the drawings. Alternate methods may be proposed for review. Engineer shall judge equivalency based upon all design requirements, environmental conditions, design life, and experience with similar systems in operation.

F. Corrosion:
    1. Protection shall be provided between dissimilar metals using coatings, dialectic tapes, non-conductive washers, or other means to prevent contact. Aluminum materials proposed for use shall be proven as corrosion resistant in similar installations.
    2. Coatings shall not be used for hardware-contact surfaces, such as nuts, bolts or screws. Coatings shall not be used for bearing surfaces subject to movement due to thermal, wind, construction or other sources.

1.02 QUALITY ASSURANCE

A. References:
    1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
ASTM A193	Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low Temperature Service
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM C509	Cellular Elastomeric Preformed Gasket and Sealing Material
ASTM D412	Rubber Properties in Tension
ASTM D471	Rubber Property-Effect of Liquid
ASTM F436	Hardened Steel Washers
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS-B3.0	Welding Procedures and Performance Qualifications
AWS D1.2	Structural Welding Code - Aluminum

Reference	Title
AWS D1.6	Structural Welding Code - Stainless Steel
IBC	International Building Code

B. Manufacturer's Experience:
   1. The aluminum geodesic domes and appurtenances manufacturer shall be one who is regularly engaged in the business of designing, building, and installing aluminum geodesic domes of the type specified in this section. All aluminum geodesic domes and appurtenances provided for this contract shall be designed, coordinated, and supplied by a single manufacturer. The manufacturer must have installed and had in satisfactory use for a period of not less than 5 years, at least 5 domes of the size and type specified.

C. Warranty
   1. In addition to the guarantee requirements specified in the General Provisions, a manufacturer's warranty shall be provided for each dome system. The dome manufacturer shall warrant that the work described herein shall be free from defects in workmanship and material. The dome manufacturer shall replace or repair any faulty workmanship or defective material furnished by it that is reported to it within 1 year from the date of completion.

1.03 SUBMITTALS

A. The following submittals shall be provided as specified in Section 01 33 00:
   1. Data giving a full description of the geodesic domes and accessories proposed by the Contractor.
   2. Shop drawings showing critical dimensions, penetration sizes and locations, framing and connection details, access hatch and natural lighting panel details, perimeter seal details, and fastener and anchor bolt details. Shop drawings shall also be considered design drawings, and sealed by a Professional Engineer licensed in the State of Utah.
   3. A complete listing of materials of construction.
   4. Certified membrane material test results and a 6-inch by 6-inch sample of the membrane material as specified in paragraph 2.03 Synthetic Rubber Membrane.
   5. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and, therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration.
   6. Complete calculations demonstrating conformance with the design requirements and sealed by a Professional Engineer licensed in the State of Utah.
   7. Proposed testing protocol to demonstrate conformance with this specification section, and all associated plant process and support utility specification sections.

8. Summary of corrosion resistant measures taken to ensure expected design life. Discuss suitability of aluminum alloys proposed for this use which have been successfully used in similar environments, including project contact name and telephone number. Identify all areas where stainless steel hardware or other dissimilar metals may contact aluminum and what protective measures have been provided.

1.04 ENVIRONMENTAL CONDITIONS

A. The dome cover system provided under this section shall be designed for use at a water treatment plant with environmental conditions described in Section 01 11 80.

1.05 SHIPMENT AND STORAGE

A. Mechanical equipment provided with the dome covers shall be handled and protected during shipment and storage as specified in Section 01 66 00. All piping and other cover openings shall be capped with metal or wood for shipping and while in storage. Each system and all components and mounting hardware shall be delivered at the same time.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Acceptable manufacturers include but not limited to:
   1. CST Industries, modified to meet requirements of this specification.

2.02 MATERIALS

A. Materials for components shall be as follows:

Component	Material
Triangulated space truss	ASTM B308, 6061-T6 Aluminum struts and gussets, 6-inch minimum depth or 6005A-T61 Aluminum
Triangular closure panels	ASTM B209, 3003-H16 aluminum sheet, 16-gage minimum
Triangular natural lighting panels	1/4-inch translucent plexiglass or acrylic, full triangulated panel
Tension ring	ASTM B308, 6061-T6 aluminum, 6-inch minimum depth or 6005A-T61 Aluminum
Fasteners	ASTM F593 series 316 stainless steel
Gaskets	Neoprene ASTM C509 or silicone GE SE44/88, ozone and ultra-violet light resistant
Sealant	EPDM Dow 790 silicone, Pecora 864 silicone, or equal, ozone and ultraviolet light resistant
Support bearing pads	Teflon-faced neoprene
Anchor bolts	See Sections 05 05 20
Dormers	ASTM B308, 6061-T6 or ASTM B209, 5052-H36 aluminum, 0.09 inch minimum thickness
Doors and Hatches	5052-H36 aluminum or Type 316 stainless steel

2.03 COMPONENTS

A. General:
   1. No galvanized, painted, or plated steel shall be used anywhere in the dome.

B. Plates and Sheets:
   1. Plate and sheet material shall be mill finished on the interior and exterior. Dome shall not exhibit a bright, shiny, polished exterior which may reflect sunlight intensely. Tension ring gussets shall be 0.375-inch minimum thickness.

C. Tension Ring
   1. Design of the tension ring shall be based on the net cross section of the members and shall not include top flange protrusions, bolt holes, or structural tee legs without fasteners.

D. Gaskets:
   1. Gaskets shall be neoprene, meeting all requirements of ASTM C509.

E. Sealant:
   1. Sealants shall be resistant to ozone and ultraviolet light in accordance with Federal Specification TT-S-00230C.

F. Support Bearings:
   1. Teflon or neoprene support pads shall bear directly against stainless steel, or aluminum contact surfaces suitably protected from direct contact. Teflon shall not bear on aluminum surfaces directly. Supports may utilize a stainless steel pin in order to accommodate unleveled support conditions. Bearing support shoes shall be welded from aluminum or stainless steel plate. Support geometry and materials shall take into consideration the corrosion resistant requirements described in paragraph 1.01 Sealing.

G. Weldments:
   1. The design and fabrication of welded aluminum parts shall be in accordance with the Aluminum Association and the AWS D1.2.
   2. All structural welds and weld-affected structural components shall be inspected by the Liquid Penetrant Inspection method of examination in accordance with ASTM E165. The inspector shall be an AWS Certified Welding Inspector (CWI) in accordance with AWS D1.2. Personnel performing nondestructive testing shall be qualified as required by AWS D1.2.
   3. All structural welding of aluminum shall be performed prior to field erection of the dome.

H. Synthetic Rubber Membrane
   1. Fiberglass Reinforced 70 Durometer Grey Silicone Sheet, AMS3315, .032" +/- .005" Thick x 36" Wide Untrimmed.

I. Manway Dormers, Doors and Hardware

1. Dormers may be overbuilds with 7'-0" clear walkable area. Manway doors may either be a manufacturer-fabricated element or purchased item such as CECO (or equal). Door and frame shall either be aluminum or stainless steel, and shall be gasketed to achieve the specified degree of air-tightness. Door size shall be 3'-0" wide by 7'-0" tall, clear opening within the dormers. Door hardware shall consist of fixed hand lever inside and out (ADA conforming geometry), deadbolt keyed outside and thumb-turn inside, standard hinges, and open-limit chain with spring. Deadbolt shall be stainless steel with brass interior, and support Schlage with keying to match system currently used on site. Other hardware shall be aluminum or stainless steel per Contractor's option.

J. Bid Item

1. This Bid Item describes an exterior finish coating for all exposed elements of the dome which differs from the mill finish described above as typical. Bid Item coating shall be:
   a. Kynar 500, 1 mil DFT, color as selected by Owner.
2. Bid Item shall include prices for coatings listed above, as well as technical data regarding the coating system proposed. Technical data submitted with bid shall include coating material, application process, coating thickness and warranty against failure and fading.
3. Items to coat include dome panels, battens, manway doormer, manway door (but not hardware or steps), flashings and any visible struts or miscellaneous pieces (when viewed from the outside). Coating is not required for the hatch, roof vents, or exterior duct supports.

2.04 CONNECTIONS

A. Joints shall be designed to sustain a total resultant shear force no greater than that which would be allowed by summing the allowable shear force of the individual fasteners, based on their net cross-sectional area through the shear plane and the allowable shear stress of the material. The use of manufacturer's test data to rationalize an increase in assumed fastener strengths is prohibited. In no case shall values greater than the minimums published by the Aluminum Association and ASTM F593 for aluminum and stainless fasteners, respectively, be used.

B. A minimum of four fasteners per flange shall be used to connect the structural members to the gusset plates. No welding or thermal cutting of aluminum structural members, supports, or connections shall be allowed except for fabrication of bearing support shoes and center compression ring at the hatch due to their adverse effects on the strength of aluminum alloys. No design shall be allowed that does not bolt structural member flanges to the gusset plates at the joints.

2.05 ACCESSORIES

A. Access Hatches

1. Framing for access hatches shall be provided in the cover of the size and in the locations shown on the drawings.

B. Air Duct Connections

1. The cover manufacturer shall provide connections in the cover for attachment of the ventilation air ducts and associated exhaust fans and intake louvers as needed to achieve design ventilation of 6 air changes per hour. Duct supports shall be mounted on and/or inside the cover.
    a. Provide a full ventilation system with the delegated design of the dome. Provide delegated design plans and specifications documenting the exhaust fan, ductwork, exhaust and intake louvers.
        1) Provide with controls necessary to enable and disable ventilation system remotely.
        2) Provide DT sensor at exhaust fan to monitor.
        3) Provide with automatic dampers at intake and discharge. Interlock with exhaust fan.

C. Triangular Natural Lighting Panels:

1. Glazing shall be provided to allow daytime natural illumination within the cover as shown on the drawings. Glazing shall consist of translucent plexiglass of thickness sufficient to provide strength equivalent to nonglazed panels, minimum 1/4-inch.

2.06 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:

1. Applicable operation and maintenance information as specified in Section 01 78 23.
2. Manufacturer's written recommendations for installation and startup.
3. Installation Certification Form 43 05 11-A as specified in paragraph 3.01.
4. Training Certification Form 43 05 11-B as specified in paragraph 3.03.
5. A full set of satisfactory weld examination records as specified in paragraph 2.03 Weldments.

PART 3 EXECUTION

3.01 INSTALLATION

A. Covers complete with all accessories and system components shall be installed as specified and in conformance with the manufacturer's written instructions.

B. While it is not impossible to coat the existing structure before installing the cover, it is strongly recommended that the coating be applied first. Contractor shall take care not to damage or compromise the coating, and shall repair same at its own expense if damaged during installation or completion of the work.

C. The membrane shall be installed in continuous strips which are as long as practicable to minimize the need for field joints. The minimum length of membrane strips shall be 100 feet. Lap joints between sections of membrane shall be made with contact cement recommended by the membrane manufacturer. Joints between the membrane and aluminum structures shall be made with mechanical fasteners as shown on the drawings.

D. Dielectric and heat seal techniques may be used as an alternate to adhesives.

E. Installation shall be performed by mechanics skilled in work of this kind. The equipment shall be checked, aligned, and approved by the manufacturer's factory trained representatives. The installation and initial operation of all components shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 PERFORMANCE TESTING

A. Covers shall be tested for substantial air-tightness and other requirements as noted herein. Method of testing shall be as submitted in accordance with Section 01 33 00. Contractor shall coordinate testing with Owner and Engineer a minimum of two weeks in advance.

3.03 CLEANUP AND CLOSEOUT

A. Contractor shall clean up all excess and leftover materials from the jobsite and leave the domes, their attachment points and seals and all associated plant features in a clean, neat, serviceable condition. Maintenance supply parts shall be delivered to jobsite and stored as directed by the Owner.

END OF SECTION

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SECTION 21 11 16

FACILITY FIRE HYDRANTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies fire hydrants.

B. Type:
   1. Fire hydrants provided under this section shall be two-piece standpipe and stem, compression shutoff, dry-barrel type.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA C502	Dry-Barrel Fire Hydrants
UL 246	Hydrants for Fire-Protection Service

B. Design Requirements:
   1. Fire hydrants shall conform to AWWA C502 and shall be listed by Underwriters Laboratories Inc. in accordance with UL 246.

C. Testing:
   1. Fire hydrants shall meet the factory and field test provisions of AWWA C502.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Fire hydrants shall be Dresser, Kennedy, or equal, modified to meet specified requirements.

B. Fire hydrants shall be painted "fire hydrant red" in accordance with AWWA C502.

2.02 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Affidavit of compliance with AWWA C502.
   2. Records of standard tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. Fire hydrants shall be installed in accordance with detail G on Drawing No. GC 22.

END OF SECTION

SECTION 21 13 13

FIRE SPRINKLER SYSTEM

PART 1 GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this section.

B. Requirements of Mechanical General Provisions Sections govern the work specified in this section except the standards of NFPA #13 shall take precedence.

1.02 DESCRIPTION OF WORK:

A. Furnish all materials, equipment and supplies and perform all work and operations to design, construct and make functional a fire sprinkler system as specified herein, to provide fire protection of all areas of the City Creek Treatment Plant. The design of the fire sprinkler system shall meet the requirements of NFPA 13, 2019 edition and be in accordance with the drawings and specifications.

1.03 QUALITY ASSURANCE:

A. Materials, devices and equipment shall be Underwriters Laboratories listed or Factory Mutual approved for use in fire protection systems.

B. Shop drawings shall be prepared by an engineering technician or senior engineering technician (Level III or Level IV) NICET certified for fire sprinkler design. Include NICET certification number on the drawings. Drawings will be signed by the technician and submitted for approval under his name.

C. Fire sprinkler contractor shall be licensed as a fire sprinkler contractor in the State of Utah.

1.04 SUBMITTALS:

A. Descriptive Data: Descriptive data shall be submitted on the following items of material and/or equipment. Such data shall consist of manufacturer's or supplier's catalog information in sufficient detail to allow verification that the material and/or equipment meets the specification requirements, or is equal to that specified.

1. All control valves, backflow preventers, check valves, pipe, fittings, couplings, sprinklers, FDC, valve tamper and water flow alarm devices.

B. Prior to fabrication, prepare shop drawings for submittal to Owner. Submit four sets of drawings and hydraulic calculations to the Owner for review. After review and acceptance by the Owner, submit to any state or local jurisdiction for review. Any review comments, and associated drawing revisions, from state or local approving authorities that affect the system design shall be approved by the Owner prior to installation.

C. Upon completion of system installation the contractor shall document a 2-inch drain test, inspect the general system installation and verify the installation is complete and installed according to the approved drawings and specifications. Minor corrections and/or additions to the drawings should be “red-lined” on the As-Built drawings. Contractor shall submit As-Built drawings, and test certificates to Owner.

D. Fabrication or installation shall not proceed until all required approvals have been obtained.

1.05 SYSTEM DESCRIPTION:

A. Provide an automatic fire sprinkler system per NFPA 13 (2019 edition) to provide fire protection of all areas of the building. Work includes but is not limited to the following:
   1. Provide a new fire sprinkler riser in space provided in northeast utility room. Riser shall incorporate a double check backflow preventer, pressure gauges, 2” main drain with discharge to the exterior, water flow and valve tamper switches. See detail in paragraph 3.08.
   2. Provide a 2-1/2” x 2-1/2” x 4” wall mounted FDC near fire sprinkler riser. Mount FDC 24” to 36” above exterior grade. Connect the FDC downstream of the backflow preventer at the fire sprinkler riser.
   3. Provide an electric water flow bell on the exterior of the building near the location of the wall mounted FDC. Coordinate location and mounting height of water flow bell with Owner. Existing water flow bell may be re-used if present and functional.
   4. Provide fire sprinklers to protect all areas of the building including any combustible concealed spaces.
   5. Water filled piping shall be installed in areas where the temperature will be reliably maintained at or above 40° F. Where piping must be installed in areas with temperatures below 40°F, fill piping with antifreeze solution and isolate antifreeze solution from water filled piping with a reduced pressure zone backflow preventer.
   6. Piping shall be concealed above ceilings where ceilings are present and may be run exposed in areas without ceilings. Coordinate elevation and layout of piping with mechanical, structural, electrical, process piping and equipment. Offset piping as necessary to avoid conflicts.
   7. Install piping pitched to drain back to main riser where possible. Where trapped piping is unavoidable, provide auxiliary drain per NFPA 13.

1.06 SYSTEM DESIGN:

A. Design densities and areas of application.
   1. All areas: Ordinary hazard group 2, 0.20 gpm/sq. ft over 1,500 sq ft with 250 gpm hose allowance.
   2. The size of the remote area may be decreased in accordance with NFPA 13 11.2.3.2.3.1 where quick response sprinklers are used and the ceiling height is less than 20’.

B. Maximum coverage per sprinkler head.
   1. Ordinary Hazard: 130 sq. ft.
   2. Light Hazard: 225 sq. ft. (areas of non-combustible unobstructed construction or

3. combustible unobstructed construction with structural members more than 3’ on center)
4. Extended coverage fire sprinklers may be used where installed in accordance with NFPA 13 and manufacturer’s recommendations. Maximum spacing for extended coverage fire sprinklers shall not exceed 400 sq. ft.

c. The Fire Protection subcontractor shall perform a fire hydrant flow test in accordance with NFPA 291 after award of the contract but before beginning design of the fire sprinkler system.

D. Apply appropriate reduction factors to account for seasonal variations. Schedule all flow tests with Spanish Fork personnel. Submit a copy of the flow test report to the project engineer.

E. A minimum 10% pressure cushion shall be provided in all hydraulic calculations.

1.07 WARRANTY:

A. Materials, equipment, and workmanship shall be free from defects for 12 months from the"Date Left in Service with All Control Valves Open," shown on "Contractor's Material and Test Certificate." If any Work is found to be defective, Contractor shall promptly, without cost to Owner, and in accordance with Owner's instructions, either correct such defective Work, or if it has been rejected by Owner, remove it from the site and replace it with non-defective Work. Submit two copies of Warranty Certificates to Owner.

1.08 REFERENCES:

A. NFPA (National Fire Protection Association) 13, "Installation of Sprinkler Systems," 2019.

B. IBC (International Building Code), 2021.

C. IFC (International Fire Code), 2021 and any local amendments.

D. Underwriters Laboratories "Fire Protection Equipment Directory," current edition.

E. Factory Mutual Systems "Approval Guide," current edition.

PART 2 PRODUCTS

Materials, devices and equipment shall be Underwriters Laboratories listed or Factory Mutual approved for use in fire protection systems.

2.01 PIPE:

A. Interior Piping:
1. All piping shall be steel and shall meet or exceed the following standards: ASTM A795, ANSI/ASTM A53, ASTM A135, ANSI B36-10M, UL CRR (Corrosion Resistance Rating) minimum 1.0 for threaded pipe.

2.02 FITTINGS:

A. Interior Piping:
   1. Cast iron threaded, ANSI B16.4.
   2. Cast iron flanged, ANSI B16.1.
   3. Malleable iron threaded, ANSI B16.3.
   4. Forged steel fittings, socket welded and threaded, ANSI B16.11.
   5. Plain end couplings and fittings, saddle couplings, and clamp type couplings are not acceptable.
   6. Other types of fittings may be used, but only those investigated and listed for this service **and** approved by the project engineer.

2.03 HANGERS:

A. Hangers shall conform to the minimum requirements of NFPA 13.

2.04 SEISMIC FITTINGS AND BRACES:

A. Earthquake bracing is required and shall conform to the minimum requirements of NFPA 13.

2.05 SPRINKLER HEADS:

A. Areas without ceilings: Small frame upright, ordinary temperature, brass, glass bulb.

B. Areas with white or off-white ceilings: White (factory painted) recessed pattern fire sprinklers and escutcheons shall be used in all areas with finished ceilings. Locate sprinkler heads to minimize discharge obstructions in accordance with NFPA 13.

C. Sprinklers of intermediate and high temperature ratings shall be installed near skylights and/or other specific locations as required by NFPA 13.

D. Provide one spare head of each type for spare head cabinet and one head wrench for each type sprinkler.

E. Sprinklers in rooms/areas where chemicals produce a humid or corrosive atmosphere shall be UL listed as corrosion resistant.

2.06 VALVES:

A. Main Riser:
   1. OS&Y or butterfly pattern control valves with installed supervisory switches. Control valves shall be part of UL listed backflow prevention assembly.
   2. USC approved double check backflow preventer.
   3. 2” angle valve for main drain. Extend discharge from main drain to building exterior and terminate with a 45° galvanized elbow.

B. Fire Department Connection:
   1. Swing pattern, grooved end check valve.

2. 1/2" automatic ball drip.

2.07 FIRE DEPARTMENT CONNECTION:

A. Provide a polished brass, 2-way 2-1/2" wall mounted fire department connection with national standard threads, breakable caps and permanent escutcheon labeled "Auto. Spkr". FDC to be mouthed between 24" and 36" above finished exterior grade. Locate FDC within 150' of a fire hydrant. Coordinate with adjacent equipment and landscaping to ensure that the FDC is unobstructed. Connect FDC downstream of backflow preventer on fire riser with 4" supply line.

2.08 ALARM DEVICES:

A. Note: Devices are furnished and installed by fire sprinkler contractor and wired by electrical contractor.

B. Sprinkler Riser:
   1. Valve tamper switches: The valve tamper switches shall be SPDT electrical switches rated for 125 Vac for monitoring the position of control valves, UL listed, and FM approved.
   2. Water flow switch: Furnish and install a water flow detector on the fire sprinkler riser, designed for wet pipe sprinkler systems, listed by UL and approved by Factory Mutual. Detector shall be a vane type water flow switch installed on the system piping downstream of control valve. Activation of switch shall provide actuation of two SPDT switches rated for 125 Vac at water flows of 10 gpm or greater.

C. Exterior:
   1. Provide and install a 6" electric bell on the exterior of the building near the fire department connection. Coordinate location and mounting height with Owner. Device to be wired to power supply and flow switch by contractor.

PART 3 EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which fire sprinkler system is to be installed and notify General Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

3.02 INSTALLATION:

A. Install system in compliance with methods detailed in NFPA 13, including seismic requirements for potential for earthquake damage.

B. Offset as needed for other trades. Avoid conflict in areas of tight construction. Do not obstruct access to air control boxes, access doors, lights or other ceiling mounted equipment.

C. Close pipe openings with caps or plugs during installation. Cover and protect components of the system against dirt and chemical or mechanical injury.

D. Provide concrete splash blocks for drains and test valve discharge, etc. unless they discharge to asphalt or concrete paving. Concrete splash blocks shall be pre-fabricated, 2-1/2" thick, Amcor or Engineer approved equal.

E. Water filled piping shall only be installed in areas where temperatures will not drop below 40ºF. If piping must be installed in unheated areas, provide an antifreeze loop and fill the piping with an antifreeze solution per the requirements of NFPA 13.

F. E. Contractor is responsible for making his own job check and any necessary adjustments in the design prior to fabrication. Make final coordination with other trades and offset piping and heads as necessary. Major conflicts shall be brought to the attention of the General Contractor for resolution by the Owner.

3.03 FIELD QUALITY CONTROL:

A. Obtain permits and post bonds as required by state and local AHJ's (Authorities Having Jurisdiction).

B. Inform AHJ's of job progress. Request presence of AHJ's, perform tests, and document results using Contractor's Material and Test Certificates.

3.04 TESTING:

A. Make and pay for all tests required by applicable codes during and after completion of the work and correct and defects in the systems indicated by the tests.

B. Hydrostatically test all system piping for two hours at 200 psi with no loss in pressure and no visible leakage. Conduct the testing after all of the fire sprinkler heads and piping are installed. Have the tests witnessed by the AHJ's and Engineer. Submit a Contractor's Material and Test Certificate to the Owner upon successful completion of the testing.

C. Train the Owner's maintenance personnel in the proper operation, testing and maintenance of all installed equipment.

3.05 DISINFECTION:

A. Disinfect piping when and as required by local jurisdiction

3.06 CLEANING:

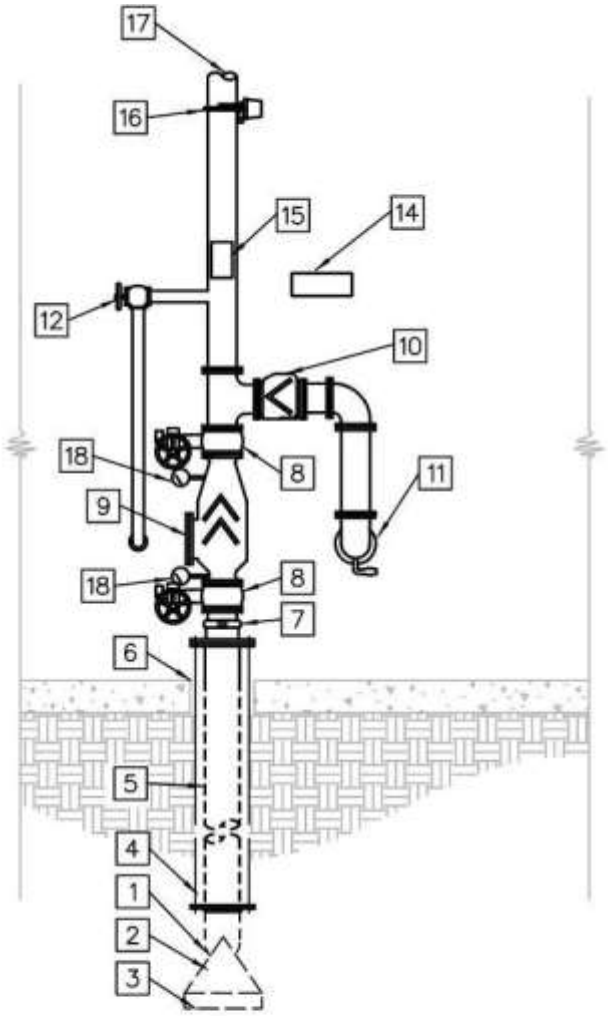
A. Remove oil, scale, debris, and foreign substances from interior and exterior of devices, equipment, and materials prior to installation.

B. Upon job completion, remove tools, surplus materials and equipment, leaving all areas broom clean.

3.07 ACCEPTANCE:

A. Acceptance of installation is subject to final inspection and approval by:
   1. Salt Lake City Fire Department.
   2. Owner or his representative.

3.08 FIRE SPRINKLER RISER SCHEMATIC:



1 — 6" UNDERGROUND SUPPLY PIPING (BEYOND)

2 — 90° M.J. BEND

3 — CONCRETE THRUST BLOCK, SIZED PER NFPA #24

4 — ANCHOR RODS, PER NFPA #24 - PROVIDE CORROSION PROTECTION

5 — CEMENT LINED DUCTILE IRON FLANGE X SPIGOT PIECE - TRANSITION FROM UNDERGROUND SUPPLY TO INTERIOR PIPING

6 — SLEEVE AT FLOOR SPACE WITH 2" CLEAR SPACE AROUND PIPE - FILL SPACE WITH MASTIC

7 — FLEXIBLE COUPLING

8 — BUTTERFLY CONTROL VALVE WITH BUILT-IN TAMPER SWITCH AND ATTACHED LOCKING CHAIN

9 — AMES COLT SERIES C200BFG DOUBLE CHECK ASSEMBLY (OR EQUAL)

10 — SWING CHECK VALVE

11 — 4" OUT TO 2-WAY FIRE DEPT. CONNECTION. PROVIDE AUTOMATIC BALL DRIP. LOCATE F.D.C 18" TO 36" ABOVE EXTERIOR GRADE.

12 — ANGLE VALVE FOR MAIN DRAIN. EXTEND DISCHARGE TO BUILDING EXTERIOR. SIZE DRAIN LINE PER NFPA 13.

13 — NOT USED

14 — SPARE SPRINKLER HEAD CABINET, PER NFPA 13

15 — HYDRAULIC CALCULATION INFORMATION SIGN.

16 — VANE TYPE WATER FLOW SWITCH

17 — SUPPLY TO FIRE SPRINKLERS

18 — PRESSURE GAUGE

FIRE SPRINKLER RISER SCHEMATIC
NTS

END OF SECTION

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SECTION 22 01 00

GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 GENERAL

A. General Conditions and Division 01 apply to this Division.

1.02 SCOPE

A. Includes -
   1. Furnish all labor, materials, and equipment necessary for the completion of the mechanical and plumbing scope of work.
   2. Furnish and install all motors specified in this Division and be responsible for the proper operation of electrical powered equipment furnished by this Division.
   3. Furnish exact location of electrical connections and information on motor controls to Division 26.
   4. Mechanical Contractor shall obtain the services of independent Test and Balance Agency.
   5. Placing the air conditioning, heating, ventilating, and exhaust systems into full operation and continuing their operation during each working day of testing and balancing.
   6. Making changes in pulleys, belts, and dampers, or adding dampers, as required for the correct balance as recommended by Balancing Contractor at no additional cost to Owner.
   7. Air balance, final adjustment and test run.
   8. The satisfactory performance of the completed systems is a requirement of this specification.
   9. Comply with FM Global requirements and recommendations for owner's insurance policy.

B. Related Work Specified Elsewhere
   1. Conduit, line voltage wiring, outlets, and disconnect switches specified in Division 26.
   2. Magnetic starters and thermal protective devices (heaters) not a factory mounted integral part of packaged equipment are specified in Division 26.

1.03 SITE OBSERVATION

A. The Contractor shall examine the site and understand the conditions which may affect the performance of work of this Division before submitting proposals for this work.

B. No subsequent allowance for time or money will be considered for any consequence related to failure to examine existing site conditions.

1.04 DRAWINGS

A. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc; however, locations are to be regarded as shown diagrammatically only. Follow as closely as actual building construction and work of other trades will permit.

B. Because of the small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate existing structural and finished conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.

C. If changes in location of piping, equipment, ducts, etc. are required due to lack of coordination of work under this division, such changes shall be made without charge. Contractor shall review drawings with local and state agencies having jurisdiction and any changes required by them shall be brought to the attention of the Engineer prior to bidding or commencement of work. It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for the installation of systems according to the true intent and meaning of the Contract Documents. Anything not clear or in conflict will be explained by making application to the Engineer in writing. Should conditions arise where certain changes would be advisable, secure Owner's and Engineer approval for these changes before proceeding with work.

1.05 COORDINATION OF WORK:

A. Coordinate work of various trades in installing interrelated work. Before installation of mechanical items, make proper provision to avoid interferences in a manner approved by Engineer. Changes required in work specified in Division 22 and 23 caused by neglect to secure approval shall be made at no cost to Owner.

B. Arrange piping, ductwork, and equipment to permit ready access to valves, unions, starters, motors, control components, and to clear openings of doors and access panels. Contractor shall provide all necessary access doors and/or panels to provide complete access to all mechanical equipment, dampers, or accessories. Doors for dampers, etc. shall be minimum 12" x 12" and doors for mechanical equipment shall be minimum 24" x 24".

C. Furnish and install inserts and supports required by Division 22 and 23 unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions involved in sufficient time to be built into the construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by Contractor.

D. Be responsible for required digging, cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of Owner and Architect. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
   1. Patch and repair walls, floors and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.

2. This Division shall bear expense of cutting, patching, repairing, and replacing of work of other Divisions because of its fault, error, tardiness, or because of damage done by it.
3. Provide the necessary cutting, patching, repairing, and replacing pavements, sidewalks, etc. to permit installation of work of this Division.

E. Adjust locations of piping, ductwork, equipment, etc, to accommodate work from interferences anticipated and encountered. Determine exact route and location of each pipe and cut prior to fabrication.
1. Make offsets, transitions, and changes in direction of piping, ductwork, and electrical raceways as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.

F. Slots and openings through floors, walls and roofs shall be provided by this Division.

G. This Contractor shall schedule his work, store his equipment and materials, and work in harmony with other Contractors so as to not delay or jeopardize the construction.

H. This Division shall coordinate with electrical contractor to insure that all required components of control work are included and fully understood. Any discrepancies shall be called to the attention of the Engineer before completion of bids. No additional cost shall accrue to the Owner as a result of lack of such coordination.

1.06 EQUIPMENT & MATERIALS:

A. Requests for substitution shall be received in writing a minimum of seven days prior to bidding. Prior acceptance shall be by Manufacturer's name only. Items not listed in this specification or subsequent addendums shall not be considered. No oral approvals will be acceptable. Manufacturers listed in this specification are acceptable only for items listed. All other items manufacturer wishes to bid must be prior approved. All equipment shall be subject to final review in accordance with "Project Submittals".

B. Product Approvals -
1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
2. In the event other than specified equipment is used and will not fit job site conditions, this Division assumes responsibility for replacement with items named in Specification.

C. Use <u>domestic made</u> pipe, pipe fittings, and motors on Project.

D. Motor and equipment name plates as well as applicable UL labels shall be in place when Project is turned over to Owner.

E. Insure that items to be furnished fit spaces available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. Do not scale off drawings.

F. All materials shall be of the best commercial quality obtainable, consistent with specified materials and for the purpose or function intended. Materials shall be new unless specifically excepted.

G. Equipment catalog or model numbers shown define the basic equipment types and quality standard only. Catalog numbers shall not be considered as all inclusive and shall be verified to include all devices, controls, operators, and appurtenances necessary for the satisfactory and complete operation of the equipment.

H. Follow manufacturer's directions in delivery, storage, protection, and installation of equipment and materials.
   1. Promptly notify Engineer in writing of conflicts between requirements of Contract Documents and Manufacturer's directions and obtain Engineer's written instructions before proceeding with work. Contractor shall bear all expenses arising from correcting deficiencies of work that does not comply with Manufacturer's directions or such written instructions.

I. Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or mechanical injury but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in a dry, heated space.

1.07 PROJECT SUBMITTALS:

A. Furnish complete catalog data for manufactured items of equipment to be used in the Work to for review within 15 days after award of Contract.

B. Submittal shall include, but not be limited to the following:
   1. equipment scheduled
   2. balancing contractor
   3. insulation
   4. grilles, and diffusers
   5. automatic temperature controls
   6. certificates of guarantee
   7. valves
   8. plumbing fixtures, accessories, and specialties
   9. any item for which more than one manufacturer is mentioned

C. Submit a minimum of five copies of data in binders and index in same order and name as they appear in Specification. - Optional: Provide electronic submittals. Electronic submittals shall be in .pdf format, and shall be compiled into a single file, with bookmarks for each piece of equipment.
   1. State sizes, capacities, brand names, motor HP, electrical requirements, accessories, materials, gauges, dimensions, and other pertinent information.
   2. List on catalog covers page numbers of submitted items.
   3. Underline or highlight applicable data.

D. If material or equipment is not as specified or submittal is not complete, it will be rejected.

E. Catalog data or shop drawings for equipment which are noted as approved shall not supersede Contract Documents.

F. Review comments shall not relieve this Division from responsibility for deviations from Contract Documents unless attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.

G. Check work described by catalog data with Contract Documents for deviations and errors.

H. All items other than first named specified equipment shall show and state all exceptions and deviations taken and shall include design calculations and drawing layouts.

I. The Contractor shall review the submittals prior to submission to make sure that the submittals are complete in all details. No submittal will be reviewed which does not bear the contractor's notation that such checking has been made.

J. No partial submittals will be considered unless approved by the Engineer.

K. Manufacturers' names shall be mentioned as acceptable prior to bidding.

L. Contractor shall verify equipment dimensions to fit the spaces provided with sufficient clearance for servicing the equipment.

M. Contractor shall review equipment submittals for compliance with schedules, specifications, and drawing plans and details. Equipment submittal shall show the proper arrangements to suit installation and maintenance such as motor location, access doors, filter removal, piping connections, etc.

N. Equipment submittal sheets shall be clearly marked indicating equipment symbol and exact selection of proposed equipment. Submittals shall clearly indicate name of manufacturer of each item.

O. For unacceptable items, the right shall be reserved to require the first named specified items.

P. Where submittals are sent with any of the above listed information missing or are incomplete they will be returned to the contractor unchecked to be completed and resubmitted. No additional time or money shall be allowed for failure to provide complete submittals on the first review.

Q. If an item requiring submittal review is ordered, purchased, shipped, or installed prior to the submittal review the item shall be removed from the job site and replaced with an approved item at contractors expense.

1.08 CLEANING & FINISHING:

A. Contractor shall, at all times, keep the premises free from waste material and rubbish. Upon completion of this Section of the work, Contractor shall remove all surplus materials and rubbish; clean all spots resulting from the mechanical work from hardware, floors, glass, walls, etc.; do all required patching up and repair all work of other trades damaged by Contractor under this Section of the work, and leave the premises in a clean orderly condition. Clean heating and cooling coils, internally and externally, and replace all air filters prior to final mechanical inspection. Remove rust, plaster, dirt, grease and oil before painting, insulating, or exposing to view the equipment, piping, ductwork, etc. in completed structure. Refinish any damaged surfaces and leave in proper working order at final completion.

1.09 EQUIPMENT SERVICING:

A. Prior to starting mechanical equipment, all motors, bearings and moving parts shall be properly oiled, greased and lubricated as required. Full and adequate maintenance service shall be given and upon completion all equipment shall be cleaned and checked and placed in perfect condition for the Owner.

B. Amount and type of lubricant shall be per manufacturer's specification.

1.10 SUPERVISION:

A. The Contractor shall supervise and direct the work with his best skill and attention. He will be solely responsible for the means, methods, techniques, sequences and procedures of construction. The Contractor will be responsible to see that the finished work complies accurately with the Contract Documents.

1.11 SAFETY REGULATIONS:

A. Contractor shall provide equipment, supervision, construction, procedures, and everything necessary to assure safety of life or property.

B. Refer also to General Condition and Special Conditions for protection clauses.

1.12 LEAK DAMAGE:

A. Contractor shall be responsible for damages to the work of other Contractors or to the building, or to its contents, people, etc., caused by leaks in any of the equipment or piping installed by him through equipment or material failures, leaking joints or disconnected pipes, fittings, or by overflows and shall make at his own expense all repairs to fixtures, building interior, contents, paint, rugs, furniture, ceiling tile, and equipment so damaged.

1.13 TOOLS AND STORAGE OF EQUIPMENT:

A. The Contractor shall furnish all necessary tools, staging and whatever may be necessary for the installation of this work and shall at all times protect this work and others, and the materials to be used therein from damage by the weather, accident and other causes, and shall repair and make good any damage thus occurring.

1.14 WORKMANSHIP:

A. Workmanship shall be the best quality of its kind for respective industries, trades, crafts and practices and shall be acceptable in every respect to the Owner and Engineer. Nothing contained herein shall relieve the Contractor from performing good work, perfect in all details of construction.

1.15 TEMPORARY FACILITIES:

A. Furnishing of temporary water, space heating, sanitary facilities, drainage lines, light and power will be as specified in Division 01 General Conditions. Contractor shall arrange to bring facilities to required location of premises. All expenses involved shall be paid by the Contractor as described in General and Special Conditions.

1.16 PAINTING BY CONTRACTOR:

A. See section 09900 for painting requirements. See also section 22 and 23 for color code requirements.

B. Painting shall be by persons experienced in painting.

C. All exposed, insulated, and bare piping, equipment, metal stands and supports shall be painted as follows:
   1. The prime coat on equipment shall be factory applied. The finish coats shall be applied under Section 09900 of these specifications.
   2. All equipment which is to be furnished in finished painted condition by Contractor shall be left without mark, scratch or impairment to finish upon completion and acceptance of job. Any necessary refinishing to match original shall be done by Contractor. Do not paint over name plates, serial numbers or other identifying marks.
   3. All new piping shall be painted as required in Section 22 and 23. Paint colors shall conform to color code requirements as specified "Identification of Piping and Equipment".

1.17 EQUIPMENT BASES:

A. Provide reinforced concrete bases under boilers, chillers, pumps, air handling units, and other equipment as necessary or as indicated on the drawings. Coordinate work with Division 03.

B. Bases shall be 6" high, above the finish floor. The base shall extend beyond the equipment 6" in all directions, where possible. Inserts and vibration isolation systems shall be provided and installed by the Mechanical Contractor at the time the concrete is poured to accommodate and anchor the equipment used. Coordinate with vibration isolation manufacturer's requirements and Section 22 and 23. Provide a one inch beveled edge all around.

1.18 BELT GUARDS:

A. Shall be provided, properly enclosing each belt drive system. Guards shall be easily removable, constructed of expanded metal with suitable frames corresponding with SMACNA standard and with tachometer openings. Coordinate with equipment suppliers to avoid duplication of belt guards supplied with equipment. Guards shall comply with OSHA Regulations.

1.19 ELECTRICAL WORK:

A. Power wiring to all electrically driven apparatus shall be done under the electrical contract. See Electrical Specifications.

B. Unless specifically noted otherwise on documents, Electrical Contractor shall furnish and install all magnetic starters including properly sized heaters, and disconnect switches as indicated on drawings or required by code.

C. The Contractor shall verify the proper operation of equipment furnished by him. Costs for repair, replacing, re-wiring and retesting shall be borne by the Contractor without additional costs to the Owner.

D. Motors shall be as specified.

1.20 CONTRACTOR'S USE OF BUILDING EQUIPMENT:

A. The Contractor may use equipment such as electric motors, fans, filters, etc. when permanently installed as part of the project and with the written permission of the Owner. As each piece of equipment is used, maintenance procedures approved by the manufacturer shall be followed, a careful record shall be kept of the time used, maintenance procedure following and of any difficulty experienced with equipment. The Contractor's records on the equipment shall be submitted to the Owner upon acceptance of project. All fan belts and filter media shall be new at the beginning of the Mechanical System Operating Test Run and System Balancing. Wearing surfaces (such as bearings) shall be carefully inspected just prior to acceptance. Any excessive wear noted shall require replacement.

1.21 INSPECTION NOTICE:

A. The following is a basic list of guideline items so that the Architect, district building inspector/Owner's representative can be at job site for these inspections as the building progresses. Mechanical Contractor shall inform these people one week in advance of test time.
   1. Water tests on all sewer, waste, and rainwater piping prior to piping being concealed.
   2. Pressure tests on all water service piping.
   3. Pressure tests on hot, chilled, and condenser water supply and return piping.
   4. All duct work prior to installation of finished ceilings, including ductwork pressure testing.
   5. The initial start-up of mechanical equipment, etc.
   6. Any changes or problems occurring at job site.
   7. Inspect all vent flashings on roof prior to roofing.

8. Periodic inspection at their discretion will be made to insure compliance to Contract Documents and codes. Contractor shall provide ladders, access and other assistance as requested during inspections.
9. Control piping pressure tests.
10. Final inspection before giving approval for final payment.

1.22 EXCAVATION AND BACKFILLING:

A. Trench for the underground gas pipe line shall be excavated to the required depth. Rocks, trash, or other debris will not be allowed in trench or backfill and shall be removed before pipe is laid in place. After piping has been tested, inspected and approved, piping shall be backfilled. All landscaping, concrete, etc., damaged by this Contractor shall be replaced by him to the satisfaction of Owner's Representative.

1.23 WARRANTY GUARANTEE:

A. The Contractor shall warrant all materials and equipment to be of quality consistent with specifications as represented by manufacturer's published data.

B. The Contractor shall guarantee that the installation and operation of the equipment shall be free from defects for a period of one year beginning at date of substantial completion and acceptance. The Contractor shall replace or repair any part of the installation that is found to be defective or incomplete within the guarantee period.

C. The one year guarantee on equipment and systems shall commence when equipment has been demonstrated to work and has been accepted. (Example: If an equipment item fails to perform and it takes 9 months after substantial completion to correct, then the guarantee shall commence after the item has been demonstrated to perform and has been accepted.)

D. Substantial completion and acceptance in no way relieves the Contractor from providing the systems and equipment as specified.

1.24 COMPLETION SCHEDULE:

A. Start-up and verification of basic equipment items shall be done prior to the date of substantial completion with sufficient time to allow balancing and adjusting to be performed.

B. At the time of the final inspection a date shall be agreed upon for completion of any remaining items. At least double the estimated cost of the work will be withheld from the Contractor's payment.

1.25 CODE REQUIREMENTS, FEES, AND PERMITS

A. The work shall be installed in accordance with the following applicable codes, ordinances and standards unless otherwise specified. The codes and standards shall include but not be limited to and be of the latest and current editions.
1. American Boiler and Affiliated Industries (AB and AI)
2. American Gas Association (AGA)
3. Air Movement and Control Association (AMCA)

4. American National Standards Institute (ANSI)
5. Air Conditioning & Refrigeration Institute (ARI)
6. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) - ASHRAE 90.1-2019
7. American Society of Mechanical Engineers (ASME)
8. American Society of Testing Materials (ASTM)
9. American Standards Association (ASA)
10. American Water Works Association (AWWA)
11. American Welding Society (AWS)
12. Associated Air Balance Council (AABC)
13. Hydraulic Institute (HI)
14. National Electrical Code (NEC)
15. National Fire Protection Association (NFPA)
16. Sheet Metal and Air Conditioning contractors National Association (SMACNA)
17. Underwriters Laboratories (UL)
18. International Building Code (IBC) 2021 Ed
19. International Mechanical Code (IMC) 2018 Ed
20. International Plumbing Code (IPC) with Utah Amendments 2021 Ed
21. International Energy Conservation Code (IECC) 2021 Ed
22. Utah State Safety Orders (OSHA/UOSH)
23. Utah Fire Rating Bureau
24. Utah Boiler and Pressure Vessel Law
25. Utah Air Conservation Regulations/Waste Disposal regulations.
26. ASHRAE Ventilation STD.62-2019
27. FM Global Current Publications and Requirements

B. Should drawings conflict with any code, the code shall govern. If drawings and specifications establish a quality exceeding the code, the drawings and specifications shall govern. If conflicts do exist among the drawings, specifications and codes, the same shall be brought to the attention of the Engineer in writing prior to bidding, otherwise Contractor shall comply with applicable codes.

C. The latest edition of all codes shall be used.

D. Contractor shall give all notices, obtain all necessary permits, file necessary plans, prepare documents and obtain approvals, and pay all fees required for completion of the mechanical and plumbing work outlined in this Division of the specifications and shown on the Mechanical Drawings.

1.26 OPERATION AND MAINTENANCE MANUAL FOR MECHANICAL SYSTEMS

A. Upon completion of work and before final payment, Contractor shall furnish and deliver to the Owner, through the Engineer, installation, operation and maintenance manuals with instructions for all new materials and equipment used in the building. The contractor shall provide three (2) hard copies of the manuals, and two (2) electronic copies of the manuals on CD or USB drive. Electronic information shall be .PDF format. The CD's shall include the same information as the hard copies, and shall be organized in the same manner with a table of contents and electronic bookmarks for each section. CD or USB drive itself shall be labeled the same as the hard copies of the manuals. Manuals may be assembled by the Div 22 or 23 contractor, by the TAB contractor, or by a third party such as Wasatch Manuals at Office: (801) 849-0442, Cell: (801) 674-9926, or Email: wasatchmanuals@gmail.com.

B. Bind Operation and Maintenance Manual for Mechanical Systems in a hard-backed three ring binder with strong sturdy cover. The project name shall be on the spine and the front of the binder. The front of the binder shall include the following information:

OPERATION

AND

MAINTENANCE

MANUAL

for MECHANICAL SYSTEMS of

(Name of Project)

(Location of Project)

(Date of Project Award)

(Name of Architect)

C. Introduction
   1. Title page including name of project, project number, date awarded and date of substantial completion.
   2. Second page shall contain the names, phone numbers and addresses of Architect, Consulting Engineers, Mechanical Contractor, and General Contractor.
   3. Third page shall include a Table of Contents for the entire manual.

D. First Section - Summary information including:
   1. First page shall contain the contractor's warranties.
   2. Second page shall contain a list of names, addresses and phone numbers of contractors and all sub-contractors and work to which each was assigned.
   3. Final page or pages shall contain an equipment list. The list shall contain each item of equipment or material for which a submittal was required giving ID or tag no as contained on the drawings make and model No. Serial No. Identification No. Location in building, function along with the name, address, and phone number of the supplier.

E. Second Section - Mechanical Equipment O&M data including:
   1. Mechanical maintenance schedule, including a lubrication list when necessary.

2. Mechanical Equipment Operation and Maintenance Data including:
    a. Equipment descriptions
    b. Detailed installation instruction, operating and maintenance instructions. Instructions include in a step by step manner identifying start-up, operating, shutdown and emergency action sequence sufficiently clear so a person unfamiliar with the equipment could perform its operations.
    c. Equipment drawings, performance curves, operating characteristics, etc.
    d. Name addresses and phone number of manufacturer, fabricator and local vender clearly printed or stamped on cover.
    e. Complete parts listing which include catalog number, serial number, contract number or other accurate provision for ordering replacement and spare parts.
    f. Certified drawings, where applicable, showing assembly of parts and general dimensions.
3. Approved Mechanical submittals

F. Third Section - Plumbing Equipment O&M data including:
1. Section shall contain general product catalog cuts, as well as exploded view drawings with parts lists for all valves and other items with multiple parts.
2. Approved Plumbing submittals

G. Fourth Section - Controls O&M data including:
1. Sequence of Operation
2. Description of each operating system included location of switches, breakers, thermostats, and control devices. Provide a single line diagram, showing set points, normal operating parameters for all loads, pressures, temperatures and flow check points; Describe all alarms and cautions for operation.
3. Provide schematic control diagrams, panel diagrams, wiring diagrams, etc. for each separate fan system, chilled water system, hot water system, exhaust air system, pumps, etc. Each control diagram shall show a schematic representation of mechanical equipment and location of start-stop switches, insertion thermostats, thermometers, pressure gauges, automatic valves, etc. The correct reading for each control instrument shall be marked on the diagram.

H. The Fifth Section shall contain a complete air and water test and balance report. The report shall contain the name, address and phone number of the agency. It shall also include:
1. Floor plans showing all air openings and thermometer locations clearly marked and cross referenced with data sheets. Format may be 8 1/2 x 11 or 11x14 if legible.
2. Data sheets showing amount of air and water at each setting. See sections 230593.
3. List of equipment with date of last calibration.

I. Drawings and reproducible masters of drawings as required in individual specification sections, are not to be bound in volumes but are to be delivered separate with the maintenance manuals.

J. See the following checklist for assistance in assembling manual:

Item #	Description	Y, N, or NA
1.	3 ring heavy duty binder with Project name, number and date on cover and project name on spine.	
2.	O&M manual on CD (with label on CD matching label on manual). Electronic copy shall be a PDF file with bookmarks that match the tabs in the hard copy.	
3.	Title Page [including project name, number, address, date awarded, date of substantial completion]	
4.	Second Page Contact List [including architect (if applicable), mechanical engineer, mechanical contractor, and general contractor (if applicable)]	
5.	Table of Contents	
6.	**Section 1 - Summary**	
A.	Warranty	
B.	Mechanical's Sub-contractor List	
C.	Vendor List	
D.	Equipment List	
7.	**Section 2 – Mechanical Equipment**	
A.	Maintenance Schedule (including lubrication list)	
B.	Mechanical Equipment O&M Data (for each piece of equipment submitted) per specifications	
C.	Approved mechanical submittals	
8.	**Section 3 – Plumbing Equipment**	
A.	Plumbing equipment O&M data	
B.	Approved plumbing submittals	
9.	**Section 4 - Controls**	
A.	Sequence of Operation	
B.	Controls diagrams	
C.	Controls Equipment	
10.	**Section 5 – Test and Balance Report**	
A.	Complete Test and Balance Report per specifications	

1.27 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Contractor shall instruct building maintenance personnel in the operation and maintenance of the installed mechanical systems utilizing the Operation and Maintenance Manual when so doing.

B. Minimum instruction periods shall be as follows -
   1. Mechanical - Two hours.
   2. Plumbing - Two hours.
   3. Temperature Control - Two hours.

C. Instruction periods shall occur before final site observation when systems are properly working and before final payment is made.

D. None of these instructional periods shall overlap each other.

E. An additional four hours of instruction will be provided by each contractor, after 60 days of system operation by owner to insure proper system operation and answer questions.

1.28 RECORD DRAWINGS

A. Contractor shall keep an up-to-date set of mechanical and plumbing drawings in his custody showing all changes in red, clearly defined and neatly drafted by him. At the end of construction, he shall turn these drawings over to the Engineer. Record drawings must be completed and submitted prior to final site observation

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 22 05 00

BASIC PLUMBING AND HVAC MATERIALS AND METHODS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Sleeves.
   5. Wall and floor penetrations
   6. Escutcheons.
   7. Mechanical demolition.
   8. Equipment installation requirements common to equipment sections.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. 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.

F. The following are industry abbreviations for plastic materials:
   1. ABS: Acrylonitrile-butadiene-styrene plastic.
   2. CPVC: Chlorinated polyvinyl chloride plastic.
   3. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Dielectric fittings.
   2. Mechanical sleeve seals.

B. Welding certificates.

1.05 QUALITY ASSURANCE

A. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

B. All materials, piping, etc. shall be new, and domestically made of the best commercial quality obtainable, consistent with specified materials and for the purpose or function intended unless specifically approved in writing prior to bid.

1.06 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.07 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical 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 mechanical items requiring access that are concealed behind finished surfaces.

PART 2 PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 and 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

A. Refer to individual Division 22 and 23 piping Sections for special joining materials not listed below.

B. 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 thickness or specific material is 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.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
   1. ABS Piping: ASTM D 2235.
   2. CPVC Piping: ASTM F 493.
   3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   4. PVC to ABS Piping Transition: ASTM D 3138.

2.03 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
   1. Available Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.

e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.
h. Prior Approved Equal.

2.04 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Available Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
      e. Linkseal.
      f. Prior Approved Equal.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel. Include two for each sealing element.
   4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.05 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

E. PVC Pipe: ASTM D 1785, Schedule 40.

2.06 PENETRATIONS

A. Floor and wall penetrations of fire rated assemblies shall be protected with FM approved fire stop systems.

2.07 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

2.08 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, non-gaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 MECHANICAL DEMOLITION

A. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

C. Coordinate with controls contractor prior to removal of any control devices.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 and 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Drawings do not show every offset, or bend that may be required. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors where indicated on drawings and where penetrating will be visible to public.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. 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. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. 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:
   4. 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.

N. 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.

O. 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.
   1. 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.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 and 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. 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.

E. 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.

F. 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.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   5. PVC Nonpressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical 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.

D. Install equipment to allow right of way for piping installed at required slope.

END OF SECTION

SECTION 22 05 23

GENERAL- DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following general-duty valves:
   1. Bronze ball valves.
   2. Ferrous-alloy ball valves.
   3. Bronze check valves.

B. Related Sections include the following:
   1. Division 22 and 23 Section "Mechanical Identification" for valve tags and charts.
   2. Division 22 and 23 Section "HVAC Instrumentation and Controls" for control valves and actuators.
   3. Division 22 and 23 piping Sections for specialty valves applicable to those Sections only.

1.03 DEFINITIONS

A. The following are standard abbreviations for valves:
   1. CWP: Cold working pressure.
   2. EPDM: Ethylene-propylene-diene terpolymer rubber.
   3. NRS: Nonrising stem.
   4. OS&Y: Outside screw and yoke.
   5. PTFE: Polytetrafluoroethylene plastic.
   6. SWP: Steam working pressure.
   7. TFE: Tetrafluoroethylene plastic.

1.04 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.05 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.
   1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.06 DELIVERY, STORAGE, AND HANDLING

A. 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 angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. 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.

C. 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 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. 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.

C. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

D. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

E. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

G. Valve Actuators:
   1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
   2. Gear Drive Operator: For quarter-turn valves NPS 8 and larger.
   3. Handwheel: For valves other than quarter-turn types.
   4. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
   5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

H. Valves in Insulated Piping: Valves shall have 2-inch stem extensions and the following features:
   1. Ball Valves: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
      a. Manufactures: NIBCO Nib-seal handle extension or a comparable product by one of the following:
         1) Conbraco Industries, Inc.; Apollo Div.
         2) American.
         3) Crane.
         4) Grinnel.
         5) Kitz.
         6) Watts.
         7) Prior approved equal.
   2. Butterfly Valves: Shall have extended necks.

I. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

J. Valve Grooved Ends: AWWA C606.

K. Solder Joint: With sockets according to ASME B16.18.
   1. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

L. Threaded: With threads according to ASME B1.20.1.

M. Valve Bypass and Drain Connections: MSS SP-45.

2.03 BRONZE BALL VALVES

A. Bronze Ball Valves, General: MSS SP-110 and have bronze body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder ends, and blowout-proof stems.

B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: Chrome-plated bronze ball and bronze stem and; reinforced TFE seats; threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, solder or threaded ends; and 150 psig SWP 600-psigCWP rating.
   1. Manufacturers: NIBCO Model S-585-70 or T-585-70, or a comparable product by one of the following:
      a. NIBCO Model S-585-70 or T-585-70
      b. American Valve, Inc.
      c. Conbraco Industries, Inc.; Apollo Div.
      d. Crane Co.; Crane Valve Group; Jenkins Valves.
      e. Crane Co.; Crane Valve Group; Stockham Div.
      f. Grinnell Corporation.
      g. Kitz Corporation of America.
      h. NIBCO INC.
      i. Watts Industries, Inc.; Water Products Div.

C. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, soldered or threaded ends; 150 psig SWP and 600-psig CWP ratings.
   1. Manufacturers: NIBCO Model S-585-70-66 or T-585-70-66, or a comparable product by one of the following:
      a. Conbraco Industries, Inc.; Apollo Div.
      b. American Valve, Inc.
      c. Conbraco Industries, Inc.; Apollo Div.
      d. Crane Co.; Crane Valve Group; Jenkins Valves.
      e. Crane Co.; Crane Valve Group; Stockham Div.
      f. Grinnell Corporation.
      g. Kitz Corporation of America.
      h. NIBCO INC.
      i. Watts Industries, Inc.; Water Products Div.
      j.

2.04 FERROUS-ALLOY BALL VALVES

A. Ferrous-Alloy Ball Valves, General: MSS SP-72, with ASTM A-216 Type WCB, carbon-steel body; ASTM A-351, Type CF8M vented stainless-steel ball; and ASTM A-276, Type 316 stainless-steel stem; fire rated according to API 607 (4th edition); and having flanged ends and blowout-proof stem.

B. Class 150, Full-Port, Ferrous-Alloy Ball Valves: Split-body construction, carbon-filled TFE seats; 285 psig CWP rating.
   1. Manufacturers:
      a. NIBCO Model F-515-CS-F-66-FS.
      b. American Valve, Inc.
      c. Conbraco Industries, Inc.; Apollo Div.

d. Cooper Cameron Corp.; Cooper Cameron Valves Div.
e. Crane Co.; Crane Valve Group; Stockham Div.
f. Foster Valve Co.
g. Hammond Valve.
h. Jomar International, LTD.
i. Kitz Corporation of America.
j. Milwaukee Valve Company.
k. Watts.

2.05 BRONZE CHECK VALVES

A. Bronze Check Valves, General: MSS SP-80.

B. Class 125, Bronze, Lift Check Valves with TFE Disc: ASTM B-584 bronze body and integral seat with soldered or threaded end connections, and having 250-psig CWP rating.
   1. Manufacturers: NIBCO Model S-480-Y or T-480-Y, or a comparable product by one of the following:
      a. Cincinnati Valve Co.
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Crane Co.; Crane Valve Group; Stockham Div.
      d. Red-White Valve Corp.
      e. Walworth Co.

C. Class 125, Bronze, Lift Check Valves with BUNA Disc: ASTM B-584 bronze body and integral seat with nonmetallic BUNA disc, soldered or threaded end connections, and having 250-psig CWP rating.
   1. Manufacturers: NIBCO Model S-480 or T-480, or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.

D. Class 300, Bronze, Swing Check Valves with Bronze Disc: ASTM B-61 bronze body and seat with regrinding-type bronze disc, Y-pattern design, threaded end connections, and having 600 psig CWP rating.
   1. Manufacturers: NIBCO Model T-473-B, or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.

E. Class 125, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.
   1. Manufacturers: NIBCO Model S-413-Y or T-413-Y, or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.

F. Class 125, Bronze, Swing Check Valves with BUNA Disc: ASTM B-62 bronze body and seat with BUNA disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.
   1. Manufacturers: NIBCO Model S-413-W or T-413-W, or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.

G. Class 150, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 300 psig CWP rating.
   1. Manufacturers: NIBCO Model S-433-Y or T-433-Y, or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. 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.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. 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.

F. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball or butterfly valves.
   2. Throttling Service: Angle, ball, butterfly, or globe valves.
   3. Pump Discharge: Spring-loaded, lift-disc or dual-plate check valves; lever and weight swing check valves; or lever and spring swing check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Domestic Water Piping: Use the following types of valves:
   1. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, bronze.
   2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full -port, ferrous alloy.
   3. Butterfly Valves, NPS 2 to NPS 12 Single-flange, full lug, 200-psig CWP rating, bronze disc, EPDM liner, ferrous alloy.
   4. Lift Check Valves, NPS 2 and Smaller: Class 125 , bronze with TFE disc.

D. Select valves, except wafer and flangeless types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for heating hot water.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
   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.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.03 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe. Butterfly valves may be installed with stem horizontal to allow support for the disc and the cleaning action of the disc.

E. Install valves in position to allow full stem movement.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

G. Butterfly valves shall be installed with stems horizontal.

3.04 JOINT CONSTRUCTION

A. Refer to Division 22 and 23 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.05 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.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR MECHANICAL AND PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
   1. Equipment nameplates.
   2. Equipment signs.
   3. Access panel and door markers.
   4. Pipe markers.
   5. Warning tags.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.04 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.05 COORDINATION

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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
   1. Data:
      a. Manufacturer, product name, model number, and serial number.
      b. Capacity, operating and power characteristics, and essential data.
      c. Labels of tested compliances.
   2. Location: Accessible and visible.
   3. Fasteners: As required to mount on equipment.

B. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
   1. Data: Instructions for operation of equipment and for safety procedures.
   2. Engraving: Manufacturer's standard letter style, 1/4” or larger with terms to match equipment identification.
   3. Thickness: 1/8 inch, unless otherwise indicated.
   4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

C. Access Panel and Door Markers: 1/16” thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8” center hole for attachment.
   1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.02 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Bradley.
      b. Kolbi.
      c. Prior approved.
   2. Colors: Comply with ASME A13.1, unless otherwise indicated.
   3. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
   4. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
   5. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
   6. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

PART 3 EXECUTION

3.01 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 22 and 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.02 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Fuel-burning units, including boilers, furnaces, heaters, etc.
   2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   3. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   4. Fans, blowers, primary balancing dampers, and mixing boxes.
   5. Packaged HVAC central-station and zone-type units.

B. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
   1. Identify mechanical equipment with black equipment markers with white lettering.
   2. Letter Size: Minimum 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-fourths the size of principal lettering.
   3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   4. Include signs for the following general categories of equipment:
      a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
      b. Fuel-burning units, including boilers, furnaces, heaters, etc.
      c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
      d. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
      e. Fans, blowers, primary balancing dampers, and mixing boxes.
      f. Packaged HVAC central-station and zone-type units.
      g. Tanks and pressure vessels.
      h. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.03 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 nonaccessible 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 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 markers.

C. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.04 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.05 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION

SECTION 22 07 00

HVAC AND PLUMBING INSULATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Mineral fiber.
   2. Insulating cements.
   3. Adhesives.
   4. Lagging adhesives.
   5. Factory-applied jackets.
   6. Field-applied jackets.
   7. Tapes.
   8. Securements.
   9. Corner angles.

B. Related Sections:
   1. Division 23 Section "Metal Ducts" for duct liners.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Qualification Data: For qualified Installer.

C. 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.

D. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. 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.

B. Fire-Test-Response Characteristics: FM Approved insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting 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 and inspecting 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.

1.05 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.

1.06 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 and 23 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.07 SCHEDULING

A. Schedule insulation application after pressure testing systems. 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 Part 3 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 C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Duct insulation shall have a minimum R value = 5 for installation in an unconditioned space, and a minimum R value = 8 for installation outdoors. Provide a weather protective sheet metal jacket for outdoor installation.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; All-Service Duct Wrap.
      f. Prior approved equal.

G. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000 Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
      f. Prior approved equal.
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A.

2.02 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Insulco, Division of MFS, Inc.; Triple I.
      b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.
      c. Prior approved equal.

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. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-127.
      b. Foster Products Corporation, H. B. Fuller Company; 85-60/ 85-70.
      c. Marathon Industries, Inc.; 225.
      d. Mon-Eco Industries, Inc.; 22-25.
      e. Prior approved equal.

2.04 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of H.B. Fuller; CR 50 AHV2.
      b. Foster Products Corporation, H. B. Fuller Company; 30-36.
      c. Vimasco Corporation; 713 and 714.
      d. Prior approved equal.
   2. Service Temperature Range: Minus 50 to plus 180 deg F.
   3. Color: White.

2.05 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 C 1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.06 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      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.
      e. Prior approved equal.
   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 C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      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.
e. Prior approved equal.

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.
8. Adhesion: 64 ounces force/inch in width.
9. Elongation: 500 percent.
10. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide one of the following:
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.
e. Prior approved equal.
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.

2.07 SECUREMENTS

A. Bands:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.
d. Prior approved equal.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

2.08 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, 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 B 209, 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 A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation 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.
   3. 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.

B. Surface Preparation: Clean and prepare surfaces to be insulated.

C. 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 equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and 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 application and finishing.

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 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.
   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 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 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 similar 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. Manholes.
   5. Handholes.
   6. Cleanouts.

3.04 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, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, 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 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 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 or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two 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 or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two 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 and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   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.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. 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 adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two 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.

3.05 MINERAL-FIBER INSULATION INSTALLATION

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 but 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 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 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.

E. 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 overcompress 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 1 edge and 1 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 deg 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 2 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.

3.06 FIELD-APPLIED JACKET INSTALLATION

A. 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.

3.07 FIELD QUALITY CONTROL

A. Tests and Inspections:
    1. Inspect ductwork, 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 one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
    2. Inspect field-insulated equipment, 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 one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
    3. 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.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.08 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, Air.
   4. Indoor, exposed return, Air.
   5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
   6. Indoor, concealed exhaust.
   7. Indoor, exposed exhaust.

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.

3.09 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, low pressure, round rectangular, and flat-oval exhaust-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Rectangular, low pressure, supply-air duct insulation shall be lined per Section “Metal Ducts”.

D. Rectangular, return-air duct insulation shall be lined per Section “Metal Ducts”.

E. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

F. Exposed or medium pressure, round and flat-oval, supply-air, and return air duct insulation shall be a perforated linear. See Section “Metal Ducts”.

3.10 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.
   4. Vertical roof drain piping.

C. Piping System insulation:
   1. Hydronic Piping - Mineral Fiber, per chart.
   2. Domestic Cold Water Piping -Mineral Fiber, ½"
   3. Domestic Hot Water Piping -Mineral Fiber, per chart
   4. Horizontal Roof Drain Piping - Mineral Fiber, 1/2".
   5. Refrigerant Piping - Flexible elastomeric, 1".

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Minimum Pipe Insulation Thickness per 2021 IECC

Fluid Operating Temperature Range and usage (F°)	Insulation Conductivity		Nominal Pipe or Tube Size (inches)				
	Conductivity Btu-in./(h-ft²-F°)	Mean Rating Temp. F°	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
Heating Systems (Steam, Steam Condensate, and Hot Water)							
>350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine, and Refrigerant)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

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. Piping, Exposed:
   1. PVC: 20 mils thick.

D. Minimum Pipe Insulation Thickness from ANSI/ASHRAE/IESNA Standard 90.1-2019, with modifications per 2021 IECC

3.13 DUCT INSULATION SCHEDULE

A. Minimum Duct Insulation R-Value, Cooling and Heating Supply Ducts and Return Ducts ANSI/ASHRAE/IES Standard 90.1-2019.

Duct Location							
Climate Zone	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insu-lation	Unconditioned Space	Indirectly Conditioned Space	Buried
Heating- Only Ducts							
5	R-6	R-3.5	none	none	none	none	R-3.5
Cooling-Only Ducts							
5,6	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none
Combine Heating and Cooling							
Supply Ducts							
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

3.14 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. Exterior piping, Exposed:
   1. Aluminum jacket.

END OF SECTION

SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Flexible connectors.
   3. Escutcheons.
   4. Sleeves and sleeve seals.
   5. Wall penetration systems.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to 2012 IBC.

1.04 SUBMITTALS

A. Product Data: For the following products:
   1. Specialty valves.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Escutcheons.
   5. Sleeves and sleeve seals.

B. Water Samples: Specified in "Cleaning" Article.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61 for potable domestic water piping and components.

1.06 PROJECT 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 Owner no fewer than two days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Owner's written permission.

1.07 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
   1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
   4. 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.

2.03 PIPING JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.04 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.

C. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.

E. Split Casting, Cast Brass: Polished, chrome-plated finish with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew or spring clips.

G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.05 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.06 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.
   5. Prior approved equal.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.07 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 EARTHWORK

A. Comply with requirements in Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 and 23 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

H. Install domestic water piping level without pitch and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install seismic restraints on piping. Comply with requirements in Division 22 and 23 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

L. 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.

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

N. Install piping adjacent to equipment and specialties to allow service and maintenance.

O. Install piping to permit valve servicing.

P. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

Q. Install piping free of sags and bends.

R. Install fittings for changes in direction and branch connections.

S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

T. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

U. Install thermometers on outlet piping from each water heater. Comply with requirements in Division 22 and 23 Section "Meters and Gages for Plumbing Piping" for thermometers.

3.03 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 pipes, tubes, and fittings before assembly.

C. 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.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.04 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 and 23 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
   1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
   2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

3.05 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 and 23 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 and 23 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
   1. Vertical Piping: MSS Type 8 or 42, clamps.

2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 15 plumbing fixture Sections for connection sizes.
   4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.08 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   4. Bare Piping in Unfinished Service Spaces: One piece, stamped steel with set screw or spring clips.
   5. Bare Piping in Equipment Rooms: One piece, stamped steel with set screw or spring clips.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:
   1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
   2. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
   3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
   4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
   5. Bare Piping in Unfinished Service Spaces: Split plate, stamped steel with exposed-rivet hinge and set screw or spring clips.
   6. Bare Piping in Equipment Rooms: Split plate, stamped steel with set screw or spring clips.
   7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.09 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:
   1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
   2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
      a. Extend sleeves 2 inches above finished floor level.
      b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 7 Section "Sheet Metal Flashing and Trim" for flashing.
   3. Sleeves for Piping Passing through Gypsum-Board Partitions:
      a. PVC pipe sleeves for pipes smaller than NPS 6.
      b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
      c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
   4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe Insert type.
   5. Sleeves for Piping Passing through Exterior Concrete Walls:
      a. Steel pipe sleeves for pipes smaller than NPS 6.
      b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
      c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
      d. Do not use sleeves when wall penetration systems are used.

6. Sleeves for Piping Passing through Interior Concrete Walls:
    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestop materials and installations.

3.10 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.11 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.12 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 and 23 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
    1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
    2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
        a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
        b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 100 psig, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.14 ADJUSTING

A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.15 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Clean non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.16 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Aboveground domestic water piping shall be the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and soldered joints.

3.17 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
   3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
   4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION

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SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Strainers.
   3. Hose bibbs.
   4. Drain valves.
   5. Circuit Setters
   6. Backflow Preventers
   7. Pressure Reducing Valves
   8. Mixing Valves
   9. Hammer Arrestors
   10. Air Vents

1.03 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 PRODUCTS

2.01 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. FEBCO; SPX Valves & Controls.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts Industries, Inc.; Water Products Div.
      h. Zurn Plumbing Products Group; Wilkins Div.
      i. Prior approved equal.
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Body: Bronze.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products, Inc.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Legend Valve.
      e. MIFAB, Inc.
      f. Prier Products, Inc.
      g. Watts Industries, Inc.; Water Products Div.
      h. Woodford Manufacturing Company.
      i. Zurn Plumbing Products Group; Light Commercial Operation.
      j. Zurn Plumbing Products Group; Wilkins Div.
      k. Prior approved equal.
   2. Standard: ASSE 1011.
   3. Body: Bronze, nonremovable, with manual drain.
   4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   5. Finish: Chrome or nickel plated.

2.02 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Drain: Factory-installed, hose-end drain valve.

2.03 HOSE BIBBS

A. Hose Bibbs:
   1. Standard: ASME A112.18.1 for sediment faucets.
   2. Body Material: Bronze.
   3. Seat: Bronze, replaceable.
   4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
   6. Pressure Rating: 125 psig.
   7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
   8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
   9. Finish for Service Areas: Chrome or nickel plated.
   10. Finish for Finished Rooms: Chrome or nickel plated.
   11. Operation for Equipment Rooms: Wheel handle or operating key.
   12. Operation for Service Areas: Wheel handle.
   13. Operation for Finished Rooms: Operating key.
   14. Include operating key with each operating-key hose bibb.
   15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.04 DRAIN VALVES

A. Ball-Valve-Type, Threaded-End Drain Valves:
   1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
   2. Pressure Rating: 400-psig minimum CWP.
   3. Size: 1.5”
   4. Body: Copper alloy.
   5. Ball: Chrome-plated brass.
   6. Seats and Seals: Replaceable.
   7. Handle: Vinyl-covered steel.
   8. Inlet: Threaded or solder joint.
   9. Outlet: Threaded, short nipple cap with brass chain.

2.05 CIRCUIT SETTERS

A. Domestic Hot Water Recirc circuit setters shall be thermostatic balance valve. Shall be one of the following manufacturers.
   1. Bell and Gossett Temp Setter or equal by:
   2. Caleffi
   3. Prior approved equal.

2.06 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
      g. Prior approved equal.
   2. Standard: ASSE 1013.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   5. Body: Bronze for NPS 2 and smaller; steel with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   7. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet ofNPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
      b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Hose-Connection Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. Watts Industries, Inc.; Water Products Div.
      c. Woodford Manufacturing Company.
      d. Prior approved equal.
   2. Standard: ASSE 1052.
   3. Operation: Up to 10-foot head of water back pressure.
   4. Inlet Size: NPS 1/2 or NPS 3/4.
   5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
   6. Capacity: At least 3-gpm flow.

2.07 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Conbraco Industries, Inc.
      c. Honeywell Water Controls.
      d. Watts Industries, Inc.; Water Products Div.
      e. Zurn Plumbing Products Group; Wilkins Div.
      f. Prior approved equal.
   2. Standard: ASSE 1003.
   3. Pressure Rating: Initial working pressure of 150 psig.
   4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
   5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.08 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Primary, Electronic, Water Mixing Valves:
   1. Approved Manufacturers:
      a. Acorn Basyc
      b. Armstrong Brain
      c. Caleffi
      d. Watts
      e. Prior approved equal
   2. Standard: ASSE 1017.
   3. Pressure Rating: 125 psig minimum unless otherwise indicated.
   4. Type: Exposed, electronically controlled, water mixing valve.
   5. Material: Bronze body with corrosion-resistant interior components.
   6. Connections: Threaded or solder joint inlets and outlet.
   7. Accessories: Manual temperature override control, check stops on hot- and cold-water supplies, and automatic hot- and cold-water shutoff upon inlet supply failure.
   8. Tempered-Water Setting: 120 .
   9. Pressure Drop at Design Flow Rate: 10 .
   10. Valve Finish: Bronze.
   11. Digital temperature control and monitoring module.
      a. Controls temperature within plus or minus 2 deg F.
      b. User programmable at module or through BAS.
      c. ASHRAE 188 compliance.
      d. Local and remote monitoring.
      e. BACNet protocol language(s).
      f. 115 V ac, 60 Hz.

g. Battery backup.

B. Individual-Fixture, Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Sloan.
b. Watts.
c. Prior approved equal.
2. Standard: ASSE 1016, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig (860 kPa) minimum, unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: 110E F.

2.09 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MIFAB, Inc.
b. Josam Company.
c. Prier Products, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Woodford Manufacturing Company.
h. Zurn Plumbing Products Group; Light Commercial Operation.
i. Zurn Plumbing Products Group; Specification Drainage Operation.
j. Or equal by.

B. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
1. Pressure Rating: 125 psig (860 kPa).
2. Operation: Loose key.
3. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
4. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
5. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
6. Box: Deep, flush mounting with cover.
7. Box and Cover Finish: Chrome plated.
8. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

9. Nozzle and Wall-Plate Finish: Polished nickel bronze.
10. Operating Keys(s): Two with each wall hydrant.

C. Vacuum Breaker Wall Hydrants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products, Inc.
      b. Mansfield Plumbing Products LLC.
      c. McDonald, A. Y. Mfg. Co.
      d. Prier Products, Inc.
      e. Smith, Jay. R. Mfg. Co.; Division of Smith Industries, Inc.
      f. Watts Industries, Inc.; Water Products Div.
      g. Woodford Manufacturing Company.
      h. Zurn Plumbing Products Group; Light Commercial Operation.
      i. Or equal by.
   2. Standard: ASSE 1019, Type A or Type B.
   3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
   4. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
   5. Pressure Rating: 125 psig (860 kPa).
   6. Operation: Loose key.
   7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
   8. Inlet: NPS 1/2 or NPS 3/4 (DN 15 or DN 20).
   9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.10 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Josam Company.
      c. MIFAB, Inc.
      d. PPP Inc.
      e. Sioux Chief Manufacturing Company, Inc.
      f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      g. Tyler Pipe; Wade Div.
      h. Watts Drainage Products Inc.
      i. Zurn Plumbing Products Group; Specification Drainage Operation.
      j. Or equal by.
   2. Standard: ASSE 1010 or PDI-WH 201.
   3. Type: Metal bellows Copper tube with piston.
   4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.11 AIR VENTS

A. Bolted-Construction Automatic Air Vents:
   1. Body: Bronze.
   2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.
   3. Float: Replaceable, corrosion-resistant metal.
   4. Mechanism and Seat: Stainless steel.
   5. Size: NPS 1/2 minimum inlet.
   6. Inlet and Vent Outlet End Connections: Threaded.

2.12 CIRCUIT SETTERS

A. Domestic Hot Water Recirc circuit setters shall be thermostatic balance valve. Shall be one of the following manufacturers.
   a. Bell and Gossett Temp Setter or equal by:
   b. Caleffi
   c. Prior approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 and 23 Section "Common work results" for piping joining materials, joint construction, and basic installation requirements.

B. Revise remaining paragraphs and subparagraphs in this Article to include specific installation requirements.

C. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

3.02 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Piping installation requirements are specified in other Division 22 and 23 Sections.

C. Drawings indicate general arrangement of piping and specialties

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

B. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

C. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.04 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION

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SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.

B. Related Sections:
   1. Division 2 Section "Sanitary Sewerage" for sanitary sewerage piping and structures outside the building.

1.03 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.\

B. Shop Drawings: For sovent drainage system. Include plans, elevations, sections, and details.

C. Seismic Qualification Certificates: For waste and vent 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. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Owner no fewer than 72 hours in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

PART 2 PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service and Extra Heavy class(es).

B. Gaskets: ASTM C 564, rubber.

2.03 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ANACO-Husky.
      b. Fernco Inc.
      c. MIFAB, Inc.
      d. Tyler Pipe.
      e. Ideal
      f. Prior approved equal.
   2. Standards: ASTM C 1277 and CISPI 310.
   3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ANACO-Husky.
      b. MIFAB, Inc.
      c. Tyler Pipe.

d. Ideal
e. Prior approved equal.

2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.04 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.
1. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Solvent Cement: ASTM D 2564.
1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Unshielded, Nonpressure Transition Couplings:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Dallas Specialty & Mfg. Co.
2) Fernco Inc.
3) Mission Rubber Company; a division of MCP Industries, Inc.
4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
5) Prior approved equal.
b. Standard: ASTM C 1173.
c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. Sleeve Materials:
1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Cascade Waterworks Mfg. Co.
        2) Mission Rubber Company; a division of MCP Industries, Inc.
        3) Prior approved equal.
    b. Standard: ASTM C 1460.
    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.
5. Pressure Transition Couplings:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following.
        1) Cascade Waterworks Mfg. Co.
        2) Dresser, Inc.
        3) EBAA Iron, Inc.
        4) JCM Industries, Inc.
        5) Romac Industries, Inc.
        6) Smith-Blair, Inc; a Sensus company.
        7) The Ford Meter Box Company, Inc.
        8) Viking Johnson.
        9) Prior approved equal.

PART 3 EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 2 Section "Earthwork."

3.02 PIPING INSTALLATION

A. 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, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. 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.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 and 23 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

L. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

O. Install aboveground ABS piping according to ASTM D 2661.

P. Install aboveground PVC piping according to ASTM D 2665.

Q. Install underground ABS and PVC piping according to ASTM D 2321.

R. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
   2. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.

3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

S. Plumbing Specialties:
   1. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 and 23 Section "Sanitary Waste Piping Specialties."
   2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 and 23 Section "Sanitary Waste Piping Specialties."
   3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 and 23 Section "Sanitary Waste Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 and 23 Section "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 and 23 Section "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 and 23 Section "Escutcheons for Plumbing Piping."

3.03 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. 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.

E. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.
   3. In Aboveground Force Main Piping: Fitting-type transition couplings.
   4. In Underground Force Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.05 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 and 23 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves:
   1. Install shutoff valve on each sewage pump discharge.
   2. Install gate or full-port ball valve for piping NPS 2 and smaller.
   3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves.
   2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Comply with requirements for backwater valve specified in Division 22 and 23 Section "Sanitary Waste Piping Specialties."

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Division 22 and 23 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 and 23 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Install individual, straight, horizontal piping runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting[, valve,] and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
   5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Comply with requirements for backwater valves cleanouts and drains specified in Division 22 and 23 Section "Sanitary Waste Piping Specialties."
   6. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.08 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 and 23 Section "Identification for Plumbing Piping and Equipment."

3.09 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste and vent piping shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.

C. Underground, soil, waste, and vent piping shall be any of the following:
   1. Extra Heavy class, cast-iron soil piping; calking materials; and calked joints.

2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION

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SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Air-admittance valves.
   4. Trap Guards.
   5. Roof flashing assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials.

1.03 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene plastic.

D. PE: Polyethylene plastic.

E. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include manufacturer, rated capacities, operating characteristics, and accessories for the following:
   1. Cleanouts.
   2. Floor drains.
   3. Air admittance valves.

1.05 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.06 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 PRODUCTS

2.01 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
      g. Prior approved equal.
   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk or raised-head, cast-iron plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.02 FLOOR DRAINS

A. Cast-Iron Floor Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Commercial Enameling Co.
      b. Josam Company; Josam Div.
      c. MIFAB, Inc.
      d. Prier Products, Inc.
      e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      f. Tyler Pipe; Wade Div.
      g. Watts Drainage Products Inc.
      h. Zurn Plumbing Products Group; Light Commercial Operation.
      i. Zurn Plumbing Products Group; Specification Drainage Operation.
      j. Prior approved equal.
   2. Standard: ASME A112.6.3.
   3. Pattern: Floor drain.

4. Body Material: Gray iron.
5. Clamping Device: Required.
6. Outlet: Bottom.
7. Top or Strainer Material: Chrome plate
8. Top or Strainer Material: Stainless steel for shower drains
9. Top Shape: Round.
10. Top Loading Classification: Medium Duty.
11. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
12. Trap Pattern: Deep-seal P-trap.
13. Trap Features: Trap-seal primer valve drain connection.

2.03 AIR-ADMITTANCE VALVES

A. Wall Box:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Durgo, Inc.
      b. Oatey.
      c. RectorSeal.
      d. Studor, Inc.
      e. Prior approved equal.
   2. Description: White plastic housing with white plastic grille, made for recessed installation. Include bottom pipe connection and space to contain one air-admittance valve.
   3. Size: About 9 inches wide by 8 inches high by 4 inches deep.

2.04 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Acorn Engineering Company; Elmdor/Stoneman Div.
      b. Thaler Metal Industries Ltd.
      c. Prior approved equal.

B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch- thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
   1. Open-Top Vent Cap: Without cap.
   2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
   3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.05 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:
   1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
   2. Size: Same as connected waste piping.
      a. NPS 2: 4-inch- minimum water seal.
      b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

B. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Trap Guard
   1. Description: Trap guard shall have flexible elastomeric material open on top, with curl closure on bottom as needed to allow water to flow, but not allow sewer gases to escape.
   2. Trap guards by Proset or prior approved equal.

2.06 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Applications: 12 oz./sq. ft. thickness.
   2. Vent Pipe Flashing: 8 oz./sq. ft. thickness.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 and 23 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

G. Install air-admittance-valve wall boxes recessed in wall where indicated on drawings.

H. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

I. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

J. Install deep-seal traps on all floor drains.

K. Install trap guards at floor drains that require trap-seal.
   1. Size: Same as floor drain inlet.

L. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

N. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.03 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.05 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.

END OF SECTION

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SECTION 22 33 00

ELECTRIC WATER HEATERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following electric water heaters:
   1. Flow-control, instantaneous electric water heaters.
   2. Light-commercial electric water heaters.
   3. Compression tanks.
   4. Water heater accessories.

1.03 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of commercial and instantaneous electric water heater, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 and 23 Section "Mechanical Vibration and Seismic Controls." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      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."
      b. 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. 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. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For electric water heaters to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

1.05 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period(s): From date of Substantial Completion:
      a. Instantaneous Electric Water Heaters: One year.
      b. Light-Commercial Electric Water Heaters:
         1) Storage Tank: Five years.
         2) Controls and Other Components: Two years.
      c. Compression Tanks: One year.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 INSTANTANEOUS ELECTRIC WATER HEATERS

A. Flow-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
   1. Manufacturers:
      a. Chronomite Laboratories, Inc.
      b. Controlled Energy Corporation.
      c. Eemax, Inc.
      d. Hot Aqua, Inc.
      e. IMI Waterheating, Ltd.
      f. Stiebel Eltron, Inc.
      g. HTP
      h. Bock
      i. Prior approved equal.
   2. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
      a. Connections: ASME B1.20.1 pipe thread.
      b. Pressure Rating: 150 psig.
      c. Heating Element: Resistance heating system.
      d. Temperature Control: Flow-control fitting.
      e. Safety Control: High-temperature-limit cutoff device or system.
      f. Jacket: Aluminum or steel with enameled finish or plastic.
   3. Support: Bracket for wall mounting.
   4. Capacity and Characteristics:
      a. Temperature Control: Flow-control fitting.
      b. See drawings for capacity, electrical service, etc.

2.03 LIGHT-COMMERCIAL ELECTRIC WATER HEATERS

A. Description: Comply with UL 174 for household, storage electric water heaters.
   1. Manufacturers:
      a. American Water Heater Company.
      b. Bradford White Corporation.
      c. Electric Heater Company (The); Hubbell Heaters Division.
      d. GSW Water Heating Company.
      e. Heat Transfer Products, Inc.

f. Lochinvar Corporation.
g. Rheem Water Heater Div.; Rheem Manufacturing Company.
h. Ruud Water Heater Div.; Rheem Manufacturing Company.
i. Smith, A. O. Water Products Company.
j. State Industries, Inc.
k. Prior approved equal.

2. Storage-Tank Construction: Steel, vertical arrangement.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
3. Factory-Installed Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
   c. Drain Valve: ASSE 1005.
   d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   e. Jacket: Steel with enameled finish.
   f. Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation, unless otherwise indicated.
   h. Temperature Control: Adjustable thermostat for each element.
   i. Safety Control: High-temperature-limit cutoff device or system.
   j. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
4. Special Requirements: NSF 5 construction with legs for off-floor installation.
5. Capacity and Characteristics:
   a. See drawings for size, capacity, electrical characteristics, etc.

2.04 COMPRESSION TANKS

A. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   1. Manufacturers:
      a. AMTROL Inc.
      b. Armstrong Pumps, Inc.
      c. Flexcon Industries.
      d. Honeywell Sparco.
      e. Myers, F. E.; Pentair Pump Group (The).
      f. Smith, A. O.; Aqua-Air Div.

g. State Industries, Inc.
h. Taco, Inc.
i. Watts Regulator Co.
j. Wessels Co.
k. Prior approved equal.

2. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
3. Capacity and Characteristics: See drawings.

2.05 WATER HEATER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.

C. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch-high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 drain outlet with ASME B1.20.1 pipe thread.

D. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches above the floor.

E. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

F. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.

G. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that are capable of isolating each water heater and of providing balanced flow through each water heater.

H. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

I. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- maximum outlet pressure, unless otherwise indicated.

J. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

PART 3 EXECUTION

3.01 WATER HEATER INSTALLATION

A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Install seismic restraints for light-commercial and commercial water heaters. Anchor to substrate.

C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 and 23 Section "Plumbing Specialties" for hose-end drain valves.

F. Install thermometer on outlet piping of water heaters. Refer to Division 22 and 23 Section "Meters and Gages" for thermometers.

G. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 22 and 23 Section "Meters and Gages" for thermometers.

H. Install pressure gage(s) on inlet and outlet of commercial electric water- heater piping. Refer to Division 22 and 23 Section "Meters and Gages" for pressure gages.

I. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 and 23 Section "Valves" for general-duty valves and to Division 22 and 23 Section "Meters and Gages" for thermometers.

J. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.

K. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

L. Fill water heaters with water.

M. Charge compression tanks with air.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial and instantaneous electric water heaters. Refer to Division 1 Section "Closeout Procedures Demonstration and Training."

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SECTION 22 34 00

FUEL-FIRED WATER HEATERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following fuel-fired water heaters:
   1. Commercial, high-efficiency, gas water heaters.
   2. Compression tanks.
   3. Water heater accessories.

1.03 DEFINITIONS

A. LP Gas: Liquefied-petroleum fuel gas.

1.04 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of commercial water heater, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 and 23 Section "Mechanical Vibration and Seismic Controls." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      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."
      b. 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. 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. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For water heaters to include in operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance:
   1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.06 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.07 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period(s): From date of Substantial Completion:
      a. Household, Gas Water Heaters:
         1) Storage Tank: Five years.
         2) Controls and Other Components: Two years.

b. Commercial, Gas Water Heaters:
   1) Storage Tank: Three years.
   2) Controls and Other Components: Three years.
c. Compression Tanks: One year(s).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 COMMERCIAL, GAS WATER HEATERS

A. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
   1. Manufacturers:
      a. AERCO International.
      b. Bradford White Corporation.
      c. Lochinvar Corporation.
      d. Patterson-Kelley.
      e. Raypak
      f. RBI Water Heaters; a Mestek, Inc. Company.
      g. Rheem Water Heater Div.; Rheem Manufacturing Company.
      h. Ruud Water Heater Div.; Rheem Manufacturing Company.
      i. Smith, A. O. Water Products Company.
      j. State Industries, Inc.
      k. HTP
      l. Bock
      m. Prior approved equal.
   2. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
   3. Factory-Installed, Storage-Tank Appurtenances:
      a. Anode Rod: Replaceable magnesium.
      b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
      e. Jacket: Steel with enameled finish.

f. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.
5. Temperature Control: Adjustable thermostat.
6. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
7. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.
8. Capacity and Characteristics: See Drawings

2.03 COMPRESSION TANKS

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

1. Available Manufacturers:
   a. AMTROL Inc.
   b. Armstrong Pumps, Inc.
   c. Flexcon Industries.
   d. Honeywell Sparco.
   e. Smith, A. O.; Aqua-Air Div.
   f. State Industries, Inc.
   g. Taco, Inc.
   h. Watts Regulator Co.
   i. Wessels Co.
   j. Prior approved equal.
2. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
3. Capacity and Characteristics: See Drawings

2.04 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

E. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.

1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

F. Water Heater Stand and Drain Pan Units: High-density-polyethylene-plastic, 18-inch-high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 drain outlet with ASME B1.20.1 pipe thread.

G. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Provide dimension that will support bottom of water heater a minimum of 18 inches above the floor.

H. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

I. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.

J. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

K. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.05 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 EXECUTION

3.01 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.
   1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   2. Concrete base construction requirements are specified in Division 22 and 23 Section "Basic Mechanical Materials and Methods."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install seismic restraints for commercial water heaters. Anchor to substrate.

D. Install gas water heaters according to NFPA 54.

E. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

F. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

G. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

H. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

J. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 and 23 Section "Plumbing Specialties" for hose-end drain valves.

K. Install thermometer on outlet piping of water heaters. Refer to Division 22 and 23 Section "Meters and Gages" for thermometers.

L. Install pressure gage(s) on inlet and outlet piping of commercial, fuel-fired water heater piping. Refer to Division 22 and 23 Section "Meters and Gages" for pressure gages.

M. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 and 23 Section "Valves" for general-duty valves and to Division 22 and 23 Section "Meters and Gages" for thermometers.

N. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

O. Fill water heaters with water.

P. Charge compression tanks with air.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water heaters. Refer to Division 1 Section "Closeout Procedures Demonstration and Training."

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SECTION 22 34 10

HIGH EFFICIENCY GAS TANKLESS DOMESTIC WATER HEATERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes packaged, factory-fabricated and assembled, gas-fired, high efficiency condensing domestic water heaters, trim and accessories for generating hot potable water.

1.03 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.

B. Pressure Drop Curve: Submit pressure drop curve for flows ranging from 0 GPM to maximum value of water heater.

C. Shop Drawings: For water heaters, water heater trim and accessories, include:
   1. Elevations, sections, details
   2. Wiring Diagrams for power

D. Operation and Maintenance Data: Data to be included in water heater emergency, operation, and maintenance manuals.

E. Warranty: Standard warranty specified in this Section.

F. Buy America Certification

1.04 QUALITY ASSURANCE

A. ETL Compliance. Condensing water heaters must be tested for compliance with ETL, "Commercial-Industrial Gas Heating Equipment." Condensing water heaters shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

B. NOx Emission Standards. When installed and operated in accordance with manufacturer’s instructions.

1.05 COORDINATION

A. Coordinate size and location of installation materials.

1.06 WARRANTY

A. Standard Warranty: Water heaters shall include manufacturer's standard form in which manufacturer agrees to repair or replace components of water heaters that fail in materials or workmanship within specified warranty period.
   1. Commercial Warranty Period for Condensing Water heaters:
      a. The pressure vessel shall carry a 6 year from shipment, non-prorated, limited warranty against any failure due to waterside corrosion, mechanical defects, or workmanship. The heat exchanger shall carry a 6 year from com- missioning, non-prorated, limited warranty against any failure due to con- densate corrosion, thermal stress, mechanical defects, or workmanship.
      b. Manufacturer labeled control panels are conditionally warranted against failure for one (1) year from commissioning.
      c. All other components are conditionally guaranteed against any failure for 1 year from commissioning.

PART 2 PRODUCTS

2.01 MANUFACTURES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Intellihot Model i200, Gen II; or a comparable product by one of the following:
   1. Intellihot i200 or equal
   2. A.O. Smith Cyclone
   3. Triangle Tube Keystone Series
   4. Lochinvar Armor Series
   5. Prior approved equal

2.02 CONSTRUCTION

A. Each water heater shall incorporate a negative Pressure gas valve on each exchanger. Each unit shall operate with a minimum Combustion Efficiency of 98% at full fire.

B. Turndown ratio 7:1, CO emissions of less than 400 ppm.)

C. Description: Water heater shall be direct fired, fully condensing, water-tube design. Power burner shall have full modulation. The minimum firing rate shall not exceed 30,000 BTU/Hr input. Water heaters that have an input greater than 30,000 BTU/Hr at minimum fire will not be considered equal. The water heater shall have the capability of discharging into a positive pressure vent. Water heater thermal efficiency shall increase with decreasing load (output), while maintaining set point. The water heater shall have an operational set point capability of 90 ºF to 185 ºF and shall maintain the outlet temperature within an accuracy of +/- 2 oF during load changes of up to 100% rated capacity. The heater shall operate quietly, less than 55 dba. Water heater shall be factory-fabricated, factory-assembled, and factory-tested, water-tube condensing water heater with heat exchanger sealed pressure-tight, built on a steel base, including a sealed insulated sheet metal enclosure that acts as combustion-air intake plenum.

D. Heat Exchanger: The heat exchanger shall be constructed with 316L stainless steel helical water tubes, fully floating with no welded joints in the exchanger. The exchanger will have a single-pass combustion gas flow design. The water tubes shall be 3/4" ID, with no less than 0.0469" wall thickness.

E. Hybrid Tank: The shell assembly of the hybrid tank vessel shall have a maximum water volume of less than .6 gallon. The water heater water connections shall be 3/4-inch Flanged O Ring connections. The shell assembly shall be constructed of 316L stainless steel of 0.0488-inch wall thickness or above.

F. Modulating Air/Fuel Valve and Burner: The water heater burner shall be capable of a 7 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall be stainless fiber mesh covering a stainless-steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless-steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. A variable frequency drive (VFD) controlled pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

G. The exhaust manifold shall be of PVC, CPVC, polypropylene, stainless steel (AL29- 4C) with a 3-inch diameter flue connection.

H. Ignition: Ignition shall be via spark ignition with 100 percent main-valve shutoff and electronic flame supervision.

2.03 CONTROLS

A. Refer to Division 23, Section "Instrumentation and Control of HVAC."

B. The water heater control system shall be a Masterless Cascading design. Lead Lag – Master / Slave control systems will not be permitted. The entire system shall be ETL recognized.

C. The control panel shall consist of one individual circuit board using state-of-the-art surface-mount technology in a single enclosure. The circuit boards shall include:
   1. A Digital touch display to indicate temperature and status.
   2. 2. A CPU board housing all control functions

D. Each board shall be individually field replaceable.

E. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

F. The unit shall have a selectable exhaust temperature limit suitable for venting with PVC or CPVC/Polypropylene/Stainless Steel (AL29-4C).

G. The controls shall annunciate water heater and sensor status and include extensive self-diagnostic capabilities.

H. The water heater control system shall incorporate the following additional features for enhanced external system interface:
   1. Temperature set point.
   2. High Exhaust temp monitor and control. Turn down the Gas valve until the exhaust temp is kept below selected material (PVC, CPVC).
   3. Cascading via RS232
   4. Error Code Display / Error Code History
      a. Blower Fault
      b. Blocked Flue Fault
      c. Ignition Failure
      d. Temp Sensor Short
      e. Temp Sensor Wiring Fault
      f. Flue Temp Fault
      g. Heat Exchanger Temp Fault
      h. Cascading Fault
      i. Water Valve Fault
      j. Pump Fault
      k. Software Fault
   5. Monitor and access to daily, weekly, monthly water usages data.
   6. Monitor inlet/outlet temperatures, flow rates, flue gas temperatures, combustion rates via onboard touchscreen.

2.04 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the water heater.

2.05 CONDENSATE

A. Condensate traps, manufactured from only non-corrosive materials.

B. Optional Accessory: Smart condensate neutralizer with capability of monitoring pH levels through included IoT app. Smart Neutralizer to also include:
   1. Monitor water temperatures.
   2. CO detection, flue gas detection, water leak detection of boiler room w/ audible/visual alarms and alerts via app.
   3. Water flow recording/monitoring.
   4. View history of above parameters via app.

2.06 VENTING

A. The exhaust vent must be for use UL Listed for use with positive pressure, condensing flue gas service. Vents of PVC, CPVC, PP, SS (AL29-4C) must be used with water heaters.

B. The minimum exhaust vent duct size for each water heater is three-inch diameter.

C. Combustion-Air Intake: Water heaters shall be capable of drawing combustion air from the outdoors via a metal or PVC, CPVC or Polypropylene duct connected between the water heater and the outdoors.

D. The minimum sealed combustion air duct size for each water heater is three-inch diameter.

E. Common Vent and Common Combustion Air up to 10 heat exchangers. Consult manufacturer for common vent and combustion air sizing.

2.07 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.

B. Test and inspect factory-assembled water heaters, before shipping.,

C. Allow Owner access to source quality-control testing of water heaters. Notify Architect fourteen days in advance of testing.

PART 3 EXECUTION

3.01 EXAMINTATION

A. Before water heater installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations. Examine piping and electrical connections to verify actual locations, sizes and other conditions affecting water heater performance, maintenance and operations.
   1. Final water heater locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where water heaters will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 WATER HEATER INSTALLATION

A. Install gas-fired water heaters in accordance with
   1. Local, stats provincial, and national codes, laws, regulations, and ordinances.
   2. National Fuel Gas Code, ANSI Z223.1/NFPA 54 – latest edition.
   3. National Electrical Code, ANSI/NFPA 70 - latest edition.
   4. Canada only: CAN/CGA B149 Installation Code and CSA C22.1 CEC Part 1.
   5. Manufacturer’s installation instructions, including required service clearances and venting guidelines.

B. Assemble and install water heater trim.

C. Install electrical devices furnished with water heater but not specified to be factory mounted.

D. Install control wiring to field-mounted electrical devices.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to the water heater to permit service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect gas piping to water heater gas valve with unions. Piping shall be at least the full size of gas train connection. Provide a reducer if required.

E. Connect hot-water piping to supply and return water heater tapping's with shutoff valve and union or flange at each connection.

F. Multiple heaters shall be piped such that all cold water entering the system will go through the heat exchanger first. A series of approved piping installation examples are shown in the installation and maintenance manuals provided with the unit. Each water heater shall have individual isolation valves for servicing and a hot water hose connection for start-up and field testing.

G. Install piping from safety relief valves to nearest floor drain.

H. Water heater Venting

I. Install flue venting kit and combustion-air intake.

J. Connect venting full size to water heater connections. Comply with requirements in Division 23 Section "Breechings, Chimneys and Stacks."

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   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. Tests and Inspections
   1. Installation and Startup Test: Perform installation and startup checks according to manufacturer's written instructions.

2. Leak Test: Perform hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion, if necessary.
4. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 2 months of the date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to the project during other than normal occupancy hours for this purpose.

E. Performance Tests
1. The water heater manufacturer is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the water heater manufacturer to complete the following performance tests:
    a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
    b. Water heaters shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
    c. Perform field performance tests to determine capacity and efficiency of water heaters.
        1) Test for full capacity.
        2) Test for water heater efficiency at low fire, 20, 40, 60, 80, 100, 80, 60, 40 and 20 percent of full capacity. Determine efficiency at each test point.
        3)
2. Repeat tests until results comply with requirements indicated.
3. Provide analysis equipment required to determine performance.
4. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
5. Notify Architect in advance of test dates.
6. Document test results in a report and submit to Architect.

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SECTION 22 40 00

PLUMBING FIXTURES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Lavatories.
   2. Lavatory Faucets.
   3. Water closets.
   4. Toilet seats.
   5. Flushometers - Water Closets.
   6. Fixture supports.
   7. Protective shielding guards.

B. Related Sections include the following:
   1. Division 22 Section "Plumbing Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.03 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.04 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Operation and Maintenance Data: For plumbing fixtures to include in operation, and maintenance manuals.

C. Warranty: Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
   3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
   4. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
   5. Vitreous-China Fixtures: ASME A112.19.2M.
   6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
   7. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   4. Faucets: ASME A112.18.1.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.
   6. Hose-Coupling Threads: ASME B1.20.7.
   7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   8. NSF Potable-Water Materials: NSF 61.
   9. Pipe Threads: ASME B1.20.1.
   10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   11. Supply Fittings: ASME A112.18.1.
   12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Manual-Operation Flushometers: ASSE 1037.
   4. Plastic Tubular Fittings: ASTM F 409.
   5. Brass Waste Fittings: ASME A112.18.2.
   6. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Disposers: ASSE 1008 and UL 430.
   2. Flexible Water Connectors: ASME A112.18.6.
   3. Floor Drains: ASME A112.6.3.
   4. Grab Bars: ASTM F 446.
   5. Hose-Coupling Threads: ASME B1.20.7.
   6. Hot-Water Dispensers: ASSE 1023 and UL 499.
   7. Off-Floor Fixture Supports: ASME A112.6.1M.
   8. Pipe Threads: ASME B1.20.1.
   9. Plastic Toilet Seats: ANSI Z124.5.
   10. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.06 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures of unit shell.
      b. Faulty operation of controls, blowers, pumps, heaters, and timers.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period: One year from date of Substantial Completion.

1.07 EXTRA MATERIALS

A. 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
   2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
   3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 2 of each type.
   4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.

PART 2 PRODUCTS

2.01 LAVATORIES

A. Lavatories:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Inc.
      b. Commercial Enameling Company.
      c. Eljer.
      d. Kohler Co.
      e. Crane.
      f. Sloan
      g. Zurn.
   2. Description: Accessible, wall-mounting, vitreous-china fixture.
      a. Type: With back.
      b. Size: 20 by 18 inches rectangular.
      c. Faucet Hole Punching: Three holes, 4-inch centers.

d. Color: White.
e. Supplies: NPS 3/8 chrome-plated copper with stops.
f. Drain: Grid with offset waste.
1) Location: Near back of bowl.

B. Lavatories, Counter Mounted:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Commercial Enameling Company.
b. Eljer.
c. Kohler Co.
d. American Standard.
e. Crane.
f. Sloan
g. Zurn.
h. Prior approved equal.
2. Description: Accessible Counter-mounting, vitreous-china fixture.
a. Type: Self-rimming.
b. Oval Lavatory Size: 20 by 17 inches.
c. Faucet Hole Punching: Three holes, 4-inch centers.
d. Color: White.
e. Supplies: NPS 3/8 chrome-plated copper with stops.
f. Drain: Grid with offset waste.
1) Location: Near back of bowl.

C. Mixing valve:
1. Valve shall be thermostatic and pressure mixing valve with maximum 5 degree approach temperature.
2. Approved Manufacturers -
a. Powers hydroguard TP or equal by
b. Sloan
c. Prior approved equal

2.02 LAVATORY FAUCETS

A. Lavatory Faucets:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Standard Companies, Inc.
b. Bradley Corporation.
c. Chicago Faucets.
d. Delta Faucet Company.
e. Eljer.
f. Elkay Manufacturing Co.

g. Fisher Manufacturing Co.
h. Just Manufacturing Company.
i. Kohler Co.
j. Moen, Inc.
k. Royal Brass Mfg. Co.
l. Sayco; a Briggs Plumbing Products, Inc. Company.
m. Speakman Company.
n. Sloan
o. T & S Brass and Bronze Works, Inc.
p. Zurn Plumbing Products Group; Commercial Brass Operation.
q. Prior approved equal.

2. Description: Sensor. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   a. Body Material: Commercial, solid brass.
   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 0.5 gpm.
   d. Centers: 4 inches.
   e. Mounting: Deck, concealed.
   f. Spout: Rigid type.
   g. Spout Outlet: Aerator.
   h. Drain: Grid.
   i. Tempering Device: Thermostatic.

2.03 WATER CLOSETS

A. Water Closets, Wall Mounted Flush Valve:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kohler Co. K-4330-ET or equal by
         1) Zurn.
         2) American Standard Companies, Inc. AFT Wall Water Saver 2257.103.
         3) Crane Plumbing, L.L.C./Fiat Products.
         4) Eljer.
         5) Sloan
         6) Toto
         7) Prior approved equal.
   2. Description Accessible, Where indicated on drawings, wall Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
      a. Style: Flushometer valve.
         1) Bowl Type: Elongated with siphon-jet design.
         2) Design Consumption: 1.6 gal./flush.
         3) Color: White.
      b. Flushometer.

B. Water Closets, Floor mounted-flushvalve:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Inc. 3043.001 (ADA), 2234.001 (standard) or equal by
         1) Briggs Plumbing Products, Inc.
         2) Crane Plumbing, L.L.C./Fiat Products.
         3) Eljer.
         4) Kohler Co.
         5) TOTO USA, Inc.
         6) Sloan
         7) Zurn.
   2. Description: Accessible where indicated on drawings, Floor-mounting, floor-outlet, vitreous-china fixture designed for flushometer valve operation.
         1) Bowl Type: Elongated front with siphon-jet design. Include bolt caps matching fixture.
         2) Height: Accessible where indicated on drawings.
         3) Design Consumption: 1.6 gal./flush.
         4) Color: White.

C. Water Closets, Floor mounted-tank type:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Inc. Cadet 2292.100 or Cadet 2168.100.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Eljer.
      d. Kohler Co.
      e. Sloan
      f. Zurn.
      g. Toto
      h. Prior approved equal.
   2. Description Accessible, where indicated on drawings, Floor-mounting, back-outlet, vitreous-china fixture designed for gravity-tank operation.
      a. Style:
         1) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
         2) Height: Accessible, where indicated on drawings.
         3) Design Consumption.
         4) Tank: Gravity type with trim. Include cover.
         5) Trip Mechanism: Lever-handle actuator.
         6) Color: White.

2.04 TOILET SEATS

A. Toilet Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Comfort seats C108SSCAM or equal.
      b. American Standard Companies, Inc.
      c. Bemis Manufacturing Company.
      d. Church Seats.
      e. Eljer.
      f. Kohler Co.
      g. Olsonite Corp.
   2. Description: Toilet seat for water-closet-type fixture.
      a. Material: Molded, heavy duty, solid, anti-microbial plastic.
      b. Configuration: Open front without cover.
      c. Hinge Type: Stainless Steel, self-sustaining.
      d. Class: Standard commercial.
      e. Color: White.

2.05 FLUSHOMETERS-WATER CLOSETS

A. Flushometers, Water Closets:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Coyne & Delany Co.
      b. Sloan Valve Company.
      c. Zurn Plumbing Products Group.
      d. Prior approved equal
   2. Description: Flushometer for water closet fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
      a. Internal Design: Diaphragm operation.
      b. Style: Exposed.
      c. Inlet Size: NPS 1".
      d. Trip Mechanism: Battery-operated sensor actuator.
      e. Consumption: 1.6 gal./flush.

2.06 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Josam Company.
   2. MIFAB Manufacturing Inc.
   3. Smith, Jay R. Mfg. Co.

4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.
7. Prior approved equal.

B. Water-Closet Supports:
1. Description: Combination carrier designed for accessible or standard mounting height as required of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:
1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:
1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

E. Sink Supports:
1. Description: Type II, sink carrier with hanger plate, bearing studs, and tie rod for sink-type fixture. Include steel uprights with feet.

2.07 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Piping Enclosures:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. TRUEBRO, Inc.
b. Plumberex.
c. McGuire.
d. Proflo.
e. Prior approved equal.
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.08 SERVICE SINKS

A. Service Sinks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Standard Companies, Inc.

b. Commercial Enameling Company.
c. Eljer.
d. Kohler Co.

2. Description: Floor-mounting, enameled, cast-iron fixture with front apron, raised back, and coated, wire rim guard.
   a. Size: 28 by 28 inches.
   b. Color: White.
   c. Faucet: Sink American Standard 8344.111 with threaded spout and48 inch hose and damp or equal by
      1) Eljer.
      2) Kohler.
      3) Speakman.
   d. Drain: Grid with NPS 2 outlet.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 and 23 Section "Valves."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

S. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

T. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 and 23 Section "Basic Mechanical Materials and Methods."

U. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.05 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust all fixtures. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

E. Install fresh batteries in sensor-operated mechanisms.

3.06 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.07 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

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SECTION 22 45 00

EMERGENCY PLUMBING FIXTURES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Eye/face wash equipment.
   2. Combination units.
   3. Supplemental equipment.
   4. Water-tempering equipment.

1.03 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

D. Tepid: Moderately warm.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.05 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. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

D. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

PART 2 PRODUCTS

2.01 EYE/FACE WASH EQUIPMENT

A. Accessible, Freestanding, Plumbed, Eye/Face Wash Units,:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Bradley Corporation.
      c. Guardian Equipment Co.
      d. Stingray Systems
      e. Prior approved equal
   2. Capacity: Not less than 3 gpm for at least 15 minutes.
   3. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   4. Control-Valve Actuator: Paddle.
   5. Spray-Head Assembly: Two or four receptor-mounted spray heads.
   6. Receptor: Plastic bowl.
   7. Drain Piping: NPS 1-1/4 minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.
   8. Mounting: Offset pedestal.
   9. Special Construction: Comply with ICC/ANSI A117.1.

2.02 COMBINATION UNITS

A. Accessible, Plumbed Emergency Shower with Eyewash Combination Units,:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Bradley Corporation.
      c. Guardian Equipment Co.
      d. Stingray Systems
      e. Prior approved equal
   2. Piping:
      a. Material: PVC.

b. Unit Supply: NPS 1-1/2.
c. Unit Drain: Outlet at back or side near bottom.

3. Shower:
   a. Capacity: Not less than 20 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Pull rod.
   d. Shower Head: 8-inch- minimum diameter, plastic.
   e. Mounting: Pedestal.
4. Eyewash Unit:
   a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle.
   d. Spray-Head Assembly: Two receptor-mounted spray heads.
   e. Receptor: Plastic bowl.
   f. Mounting: Attached shower pedestal.
   g. Drench-Hose Option: May be provided instead of eyewash unit.
      1) Capacity: Not less than 0.4 gpm for at least 15 minutes.
      2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
      3) Mounting: Bracket on shower pedestal.

2.03 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment,:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Armstrong International, Inc.
      c. Bradley Corporation.
      d. Encon Safety Products.
      e. Guardian Equipment Co.
      f. Haws Corporation.
      g. Lawler Manufacturing Co., Inc.
      h. Leonard Valve Company.
      i. Powers; a division of Watts Water Technologies, Inc.
      j. Speakman Company.
      k. Prior approved equal
   2. Description: Factory-fabricated equipment with thermostatic mixing valve.
      a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
      b. Supply Connections: For hot and cold water.

2.04 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Division 22 and 23 Section "General-Duty Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Division 22 and 23 Section "Steam and Condensate Piping."

F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Division 22 and 23 Section "Domestic Water Piping."

G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Division 22 and 23 Section "Meters and Gages for Plumbing Piping."

H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Division 22 and 23 Section "Sanitary Waste and Vent Piping."

I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Division 22 and 23 Section "Sanitary Waste and Vent Piping."

J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Division 22 and 23 Section "Escutcheons for Plumbing Piping."

K. Fill self-contained fixtures with flushing fluid.

3.03 CONNECTIONS

A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Division 22 and 23 Section "Domestic Water Piping."

B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Division 22 Section "Domestic Water Piping."

C. Connect steam and cold-water-supply and condensate return piping to steam and cold water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for cold-water piping specified in Division 22 Section "Domestic Water Piping" and comply with requirements for steam and condensate piping specified in Division 22 and 23 Section "Steam and Condensate Piping."

D. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Division 22 Section "Domestic Water Piping."

E. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Division 22 Section "Sanitary Waste and Vent Piping."

F. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

G. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.04 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Division 22 and 23 Section "Identification for Plumbing Piping and Equipment."

3.05 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and re-test until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION

SECTION 23 01 00

GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 GENERAL

A. General Conditions and Division 01 apply to this Division.

1.02 SCOPE

A. Includes:
   1. Furnish all labor, materials, and equipment necessary for the completion of the mechanical and plumbing scope of work.
   2. Furnish and install all motors specified in this Division and be responsible for the proper operation of electrical powered equipment furnished by this Division.
   3. Furnish exact location of electrical connections and information on motor controls to Division 26.
   4. Mechanical Contractor shall obtain the services of independent Test and Balance Agency.
   5. Placing the air conditioning, heating, ventilating, and exhaust systems into full operation and continuing their operation during each working day of testing and balancing.
   6. Making changes in pulleys, belts, and dampers, or adding dampers, as required for the correct balance as recommended by Balancing Contractor at no additional cost to Owner.
   7. Air balance, final adjustment and test run.
   8. The satisfactory performance of the completed systems is a requirement of this specification.

B. Related Work Specified Elsewhere
   1. Conduit, line voltage wiring, outlets, and disconnect switches specified in Division 26.
   2. Magnetic starters and thermal protective devices (heaters) not a factory mounted integral part of packaged equipment are specified in Division 26.

1.03 SITE OBSERVATION

A. The Contractor shall examine the site and understand the conditions which may affect the performance of work of this Division before submitting proposals for this work.

B. No subsequent allowance for time or money will be considered for any consequence related to failure to examine existing site conditions.

1.04 DRAWINGS

A. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc; however, locations are to be regarded as shown diagrammatically only. Follow as closely as actual building construction and work of other trades will permit.

B. Because of the small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate existing structural and finished conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.

C. If changes in location of piping, equipment, ducts, etc. are required due to lack of coordination of work under this division, such changes shall be made without charge. Contractor shall review drawings with local and state agencies having jurisdiction and any changes required by them shall be brought to the attention of the Engineer prior to bidding or commencement of work. It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for the installation of systems according to the true intent and meaning of the Contract Documents. Anything not clear or in conflict will be explained by making application to the Engineer in writing. Should conditions arise where certain changes would be advisable, secure Owner's and Engineer approval for these changes before proceeding with work.

1.05 COORDINATION OF WORK:

A. Coordinate work of various trades in installing interrelated work. Before installation of mechanical items, make proper provision to avoid interferences in a manner approved by Engineer. Changes required in work specified in Division 22 and 23 caused by neglect to secure approval shall be made at no cost to Owner.

B. Arrange piping, ductwork, and equipment to permit ready access to valves, unions, starters, motors, control components, and to clear openings of doors and access panels. Contractor shall provide all necessary access doors and/or panels to provide complete access to all mechanical equipment, dampers, or accessories. Doors for dampers, etc. shall be minimum 12" x 12" and doors for mechanical equipment shall be minimum 24" x 24".

C. Furnish and install inserts and supports required by Division 22 and 23 unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions involved in sufficient time to be built into the construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by Contractor.

D. Be responsible for required digging, cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of Owner and Architect. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
   1. Patch and repair walls, floors and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
   2. This Division shall bear expense of cutting, patching, repairing, and replacing of work of other Divisions because of its fault, error, tardiness, or because of damage done by it.
   3. Provide the necessary cutting, patching, repairing, and replacing pavements, sidewalks, etc. to permit installation of work of this Division.

E. Adjust locations of piping, ductwork, equipment, etc, to accommodate work from interferences anticipated and encountered. Determine exact route and location of each pipe and cut prior to fabrication.

1. Make offsets, transitions, and changes in direction of piping, ductwork, and electrical raceways as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.

F. Slots and openings through floors, walls and roofs shall be provided by this Division.

G. This Contractor shall schedule his work, store his equipment and materials, and work in harmony with other Contractors so as to not delay or jeopardize the construction.

H. This Division shall coordinate with electrical contractor to insure that all required components of control work are included and fully understood. Any discrepancies shall be called to the attention of the Engineer before completion of bids. No additional cost shall accrue to the Owner as a result of lack of such coordination.

1.06 EQUIPMENT & MATERIALS:

A. Requests for substitution shall be received in writing a minimum of seven days prior to bidding. Prior acceptance shall be by Manufacturer's name only. Items not listed in this specification or subsequent addendums shall not be considered. No oral approvals will be acceptable. Manufacturers listed in this specification are acceptable only for items listed. All other items manufacturer wishes to bid must be prior approved. All equipment shall be subject to final review in accordance with "Project Submittals".

B. Product Approvals -

1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
2. In the event other than specified equipment is used and will not fit job site conditions, this Division assumes responsibility for replacement with items named in Specification.

C. Use <u>domestic made</u> pipe, pipe fittings, and motors on Project.

D. Motor and equipment name plates as well as applicable UL labels shall be in place when Project is turned over to Owner.

E. Insure that items to be furnished fit spaces available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. Do not scale off drawings.

F. All materials shall be of the best commercial quality obtainable, consistent with specified materials and for the purpose or function intended. Materials shall be new unless specifically excepted.

G. Equipment catalog or model numbers shown define the basic equipment types and quality standard only. Catalog numbers shall not be considered as all inclusive and shall be verified to include all devices, controls, operators, and appurtenances necessary for the satisfactory and complete operation of the equipment.

H. Follow manufacturer's directions in delivery, storage, protection, and installation of equipment and materials.
   1. Promptly notify Engineer in writing of conflicts between requirements of Contract Documents and Manufacturer's directions and obtain Engineer's written instructions before proceeding with work. Contractor shall bear all expenses arising from correcting deficiencies of work that does not comply with Manufacturer's directions or such written instructions.

I. Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or mechanical injury but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in a dry, heated space.

1.07 PROJECT SUBMITTALS:

A. Furnish complete catalog data for manufactured items of equipment to be used in the Work to for review within 15 days after award of Contract.

B. Submittal shall include, but not be limited to the following:
   1. equipment scheduled
   2. balancing contractor
   3. insulation
   4. grilles, and diffusers
   5. automatic temperature controls
   6. certificates of guarantee
   7. valves
   8. plumbing fixtures, accessories, and specialties
   9. any item for which more than one manufacturer is mentioned

C. Submit a minimum of five copies of data in binders and index in same order and name as they appear in Specification. - Optional: Provide electronic submittals. Electronic submittals shall be in .pdf format, and shall be compiled into a single file, with bookmarks for each piece of equipment.
   1. State sizes, capacities, brand names, motor HP, electrical requirements, accessories, materials, gauges, dimensions, and other pertinent information.
   2. List on catalog covers page numbers of submitted items.
   3. Underline or highlight applicable data.

D. If material or equipment is not as specified or submittal is not complete, it will be rejected.

E. Catalog data or shop drawings for equipment which are noted as approved shall not supersede Contract Documents.

F. Review comments shall not relieve this Division from responsibility for deviations from Contract Documents unless attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.

G. Check work described by catalog data with Contract Documents for deviations and errors.

H. All items other than first named specified equipment shall show and state all exceptions and deviations taken and shall include design calculations and drawing layouts.

I. The Contractor shall review the submittals prior to submission to make sure that the submittals are complete in all details. No submittal will be reviewed which does not bear the contractor's notation that such checking has been made.

J. No partial submittals will be considered unless approved by the Engineer.

K. Manufacturers' names shall be mentioned as acceptable prior to bidding.

L. Contractor shall verify equipment dimensions to fit the spaces provided with sufficient clearance for servicing the equipment.

M. Contractor shall review equipment submittals for compliance with schedules, specifications, and drawing plans and details. Equipment submittal shall show the proper arrangements to suit installation and maintenance such as motor location, access doors, filter removal, piping connections, etc.

N. Equipment submittal sheets shall be clearly marked indicating equipment symbol and exact selection of proposed equipment. Submittals shall clearly indicate name of manufacturer of each item.

O. For unacceptable items, the right shall be reserved to require the first named specified items.

P. Where submittals are sent with any of the above listed information missing or are incomplete they will be returned to the contractor unchecked to be completed and resubmitted. No additional time or money shall be allowed for failure to provide complete submittals on the first review.

Q. If an item requiring submittal review is ordered, purchased, shipped, or installed prior to the submittal review the item shall be removed from the job site and replaced with an approved item at contractors expense.

1.08 CLEANING & FINISHING:

A. Contractor shall, at all times, keep the premises free from waste material and rubbish. Upon completion of this Section of the work, Contractor shall remove all surplus materials and rubbish; clean all spots resulting from the mechanical work from hardware, floors, glass, walls, etc.; do all required patching up and repair all work of other trades damaged by Contractor under this Section of the work, and leave the premises in a clean orderly condition. Clean heating and cooling coils, internally and externally, and replace all air filters prior to final mechanical inspection. Remove rust, plaster, dirt, grease and oil before painting, insulating, or exposing to view the equipment, piping, ductwork, etc. in completed structure. Refinish any damaged surfaces and leave in proper working order at final completion.

1.09 EQUIPMENT SERVICING:

A. Prior to starting mechanical equipment, all motors, bearings and moving parts shall be properly oiled, greased and lubricated as required. Full and adequate maintenance service shall be given and upon completion all equipment shall be cleaned and checked and placed in perfect condition for the Owner.

B. Amount and type of lubricant shall be per manufacturer's specification.

1.10 SUPERVISION:

A. The Contractor shall supervise and direct the work with his best skill and attention. He will be solely responsible for the means, methods, techniques, sequences and procedures of construction. The Contractor will be responsible to see that the finished work complies accurately with the Contract Documents.

1.11 SAFETY REGULATIONS:

A. Contractor shall provide equipment, supervision, construction, procedures, and everything necessary to assure safety of life or property.

B. Refer also to General Condition and Special Conditions for protection clauses.

1.12 LEAK DAMAGE:

A. Contractor shall be responsible for damages to the work of other Contractors or to the building, or to its contents, people, etc., caused by leaks in any of the equipment or piping installed by him through equipment or material failures, leaking joints or disconnected pipes, fittings, or by overflows and shall make at his own expense all repairs to fixtures, building interior, contents, paint, rugs, furniture, ceiling tile, and equipment so damaged.

1.13 TOOLS AND STORAGE OF EQUIPMENT:

A. The Contractor shall furnish all necessary tools, staging and whatever may be necessary for the installation of this work and shall at all times protect this work and others, and the materials to be used therein from damage by the weather, accident and other causes, and shall repair and make good any damage thus occurring.

1.14 WORKMANSHIP:

A. Workmanship shall be the best quality of its kind for respective industries, trades, crafts and practices and shall be acceptable in every respect to the Owner and Engineer. Nothing contained herein shall relieve the Contractor from performing good work, perfect in all details of construction.

1.15 TEMPORARY FACILITIES:

A. Furnishing of temporary water, space heating, sanitary facilities, drainage lines, light and power will be as specified in Division 01 General Conditions. Contractor shall arrange to bring facilities to required location of premises. All expenses involved shall be paid by the Contractor as described in General and Special Conditions.

1.16 PAINTING BY CONTRACTOR:

A. Painting shall be by persons experienced in painting.

1.17 EQUIPMENT BASES:

A. Provide reinforced concrete bases under boilers, chillers, pumps, air handling units, and other equipment as necessary or as indicated on the drawings. Coordinate work with Division 03.

B. Bases shall be 6" high, above the finish floor. The base shall extend beyond the equipment 6" in all directions, where possible. Inserts and vibration isolation systems shall be provided and installed by the Mechanical Contractor at the time the concrete is poured to accommodate and anchor the equipment used. Coordinate with vibration isolation manufacturer's requirements and Section 22 and 23. Provide a one inch beveled edge all around.

1.18 BELT GUARDS:

A. Shall be provided, properly enclosing each belt drive system. Guards shall be easily removable, constructed of expanded metal with suitable frames corresponding with SMACNA standard and with tachometer openings. Coordinate with equipment suppliers to avoid duplication of belt guards supplied with equipment. Guards shall comply with OSHA Regulations.

1.19 ELECTRICAL WORK:

A. Power wiring to all electrically driven apparatus shall be done under the electrical contract. See Electrical Specifications.

B. Unless specifically noted otherwise on documents, Electrical Contractor shall furnish and install all magnetic starters including properly sized heaters, and disconnect switches as indicated on drawings or required by code.

C. The Contractor shall verify the proper operation of equipment furnished by him. Costs for repair, replacing, re-wiring and retesting shall be borne by the Contractor without additional costs to the Owner.

D. Motors shall be as specified.

1.20 CONTRACTOR'S USE OF BUILDING EQUIPMENT:

A. The Contractor may use equipment such as electric motors, fans, filters, etc. when permanently installed as part of the project and with the written permission of the Owner. As each piece of equipment is used, maintenance procedures approved by the manufacturer shall be followed, a careful record shall be kept of the time used, maintenance procedure following and of any difficulty experienced with equipment. The Contractor's records on the equipment shall be submitted to the Owner upon acceptance of project. All fan belts and filter media shall be new at the beginning of the Mechanical System Operating Test Run and System Balancing. Wearing surfaces (such as bearings) shall be carefully inspected just prior to acceptance. Any excessive wear noted shall require replacement.

1.21 INSPECTION NOTICE:

A. The following is a basic list of guideline items so that the Architect, district building inspector/Owner’s representative can be at job site for these inspections as the building progresses. Mechanical Contractor shall inform these people one week in advance of test time.
   1. Water tests on all sewer, waste, and rainwater piping prior to piping being concealed.
   2. Pressure tests on all water service piping.
   3. Pressure tests on hot, chilled, and condenser water supply and return piping.
   4. All duct work prior to installation of finished ceilings, including ductwork pressure testing.
   5. The initial start-up of mechanical equipment, etc.
   6. Any changes or problems occurring at job site.
   7. Inspect all vent flashings on roof prior to roofing.
   8. Periodic inspection at their discretion will be made to insure compliance to Contract Documents and codes. Contractor shall provide ladders, access and other assistance as requested during inspections.
   9. Control piping pressure tests.
   10. Final inspection before giving approval for final payment.

1.22 EXCAVATION AND BACKFILLING:

A. Trench for the underground gas pipe line shall be excavated to the required depth. Rocks, trash, or other debris will not be allowed in trench or backfill and shall be removed before pipe is laid in place. After piping has been tested, inspected and approved, piping shall be backfilled. All landscaping, concrete, etc., damaged by this Contractor shall be replaced by him to the satisfaction of Owner's Representative.

1.23 WARRANTY GUARANTEE:

A. The Contractor shall warrant all materials and equipment to be of quality consistent with specifications as represented by manufacturer's published data.

B. The Contractor shall guarantee that the installation and operation of the equipment shall be free from defects for a period of one year beginning at date of substantial completion and acceptance. The Contractor shall replace or repair any part of the installation that is found to be defective or incomplete within the guarantee period.

C. The one year guarantee on equipment and systems shall commence when equipment has been demonstrated to work and has been accepted. (Example: If an equipment item fails to perform and it takes 9 months after substantial completion to correct, then the guarantee shall commence after the item has been demonstrated to perform and has been accepted.)

D. Substantial completion and acceptance in no way relieves the Contractor from providing the systems and equipment as specified.

1.24 COMPLETION SCHEDULE:

A. Start-up and verification of basic equipment items shall be done prior to the date of substantial completion with sufficient time to allow balancing and adjusting to be performed.

B. At the time of the final inspection a date shall be agreed upon for completion of any remaining items. At least double the estimated cost of the work will be withheld from the Contractor's payment.

1.25 CODE REQUIREMENTS, FEES, AND PERMITS

A. The work shall be installed in accordance with the following applicable codes, ordinances and standards unless otherwise specified. The codes and standards shall include but not be limited to and be of the latest and current editions.
   1. American Boiler and Affiliated Industries (AB and AI)
   2. American Gas Association (AGA)
   3. Air Movement and Control Association (AMCA)
   4. American National Standards Institute (ANSI)
   5. Air Conditioning & Refrigeration Institute (ARI)
   6. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) - ASHRAE 90.1-2019
   7. American Society of Mechanical Engineers (ASME)

8. American Society of Testing Materials (ASTM)
9. American Standards Association (ASA)
10. American Water Works Association (AWWA)
11. American Welding Society (AWS)
12. Associated Air Balance Council (AABC)
13. Heat Exchange Institute (HEI)
14. Hydraulic Institute (HI)
15. National Electrical Code (NEC)
16. National Fire Protection Association (NFPA)
17. Sheet Metal and Air Conditioning contractors National Association (SMACNA)
18. Underwriters Laboratories (UL)
19. International Building Code (IBC) 2021 Ed
20. International Mechanical Code (IMC) 2021 Ed
21. International Plumbing Code (IPC) with Utah Amendments 2021 Ed
22. International Energy Conservation Code (IECC) 2021 Ed
23. Utah State Safety Orders (OSHA/UOSH)
24. Utah Fire Rating Bureau
25. Utah Boiler and Pressure Vessel Law
26. Utah Air Conservation Regulations/Waste Disposal regulations.
27. ASHRAE Ventilation STD.62-2019
28. FM Global Requirements and Regulations

B. Should drawings conflict with any code, the code shall govern. If drawings and specifications establish a quality exceeding the code, the drawings and specifications shall govern. If conflicts do exist among the drawings, specifications and codes, the same shall be brought to the attention of the Engineer in writing prior to bidding, otherwise Contractor shall comply with applicable codes.

C. The latest edition of all codes shall be used.

D. Contractor shall give all notices, obtain all necessary permits, file necessary plans, prepare documents and obtain approvals, and pay all fees required for completion of the mechanical and plumbing work outlined in this Division of the specifications and shown on the Mechanical Drawings.

1.26 OPERATION AND MAINTENANCE MANUAL FOR MECHANICAL SYSTEMS

A. Upon completion of work and before final payment, Contractor shall furnish and deliver to the Owner, through the Engineer, installation, operation and maintenance manuals with instructions for all new materials and equipment used in the building. The contractor shall provide three (3) hard copies of the manuals, and three (3) CD's with electronic copies of the manuals. Electronic information shall be .PDF format. The CD's shall include the same information as the hard copies, and shall be organized in the same manner with electronic bookmarks for each section. CD case and the CD itself shall be labeled the same as the hard copies of the manuals.

B. Bind Operation and Maintenance Manual for Mechanical Systems in a hard-backed piano hinge loose-leaf binder with strong sturdy cover. The project name shall be on the spine and the front of the binder. The front of the binder shall include the following information:

OPERATION

AND

MAINTENANCE

MANUAL

for MECHANICAL SYSTEMS of

(Name of Project)

(Location of Project)

(Date of Project Award)

(Name of Architect)

C. Introduction
   1. Title page including name of project, project number, date awarded and date of substantial completion.
   2. Second page shall contain the names, phone numbers and addresses of Architect, Consulting Engineers, Mechanical Contractor, and General Contractor.
   3. Third page shall include a Table of Contents for the entire manual.

D. First Section - Summary information including:
   1. First page shall contain the contractor's warranties.
   2. Second page shall contain a list of names, addresses and phone numbers of contractors and all sub-contractors and work to which each was assigned.
   3. Final page or pages shall contain an equipment list. The list shall contain each item of equipment or material for which a submittal was required giving ID or tag no as contained on the drawings make and model No. Serial No. Identification No. Location in building, function along with the name, address, and phone number of the supplier.

E. Second Section - Mechanical Equipment O&M data including:
   1. Mechanical maintenance schedule, including a lubrication list when necessary.
   2. Mechanical Equipment Operation and Maintenance Data including:
      a. Equipment descriptions
      b. Detailed installation instruction, operating and maintenance instructions. Instructions include in a step by step manner identifying start-up, operating, shutdown and emergency action sequence sufficiently clear so a person unfamiliar with the equipment could perform its operations.
      c. Equipment drawings, performance curves, operating characteristics, etc.
      d. Name addresses and phone number of manufacturer, fabricator and local vender clearly printed or stamped on cover.
      e. Complete parts listing which include catalog number, serial number, contract number or other accurate provision for ordering replacement and spare parts.

f. Certified drawings, where applicable, showing assembly of parts and general dimensions.

3. Approved Mechanical submittals

F. Third Section - Controls O&M data including:

1. Sequence of Operation
2. Description of each operating system included location of switches, breakers, thermostats, and control devices. Provide a single line diagram, showing set points, normal operating parameters for all loads, pressures, temperatures and flow check points; Describe all alarms and cautions for operation.
3. Provide schematic control diagrams, panel diagrams, wiring diagrams, etc. for each separate fan system, chilled water system, hot water system, exhaust air system**,** pumps, etc. Each control diagram shall show a schematic representation of mechanical equipment and location of start-stop switches, insertion thermostats, thermometers, pressure gauges, automatic valves, etc. The correct reading for each control instrument shall be marked on the diagram.

G. The Fourth Section shall contain a complete air and water test and balance report. The report shall contain the name, address and phone number of the agency. It shall also include:

1. Floor plans showing all air openings and thermometer locations clearly marked and cross referenced with data sheets. Format may be 8 1/2 x 11 or 11x14 if legible.
2. Data sheets showing amount of air and water at each setting. See sections 22 and 23.
3. List of equipment with date of last calibration.

H. Drawings and reproducible masters of drawings as required in individual specification sections, are not to be bound in volumes but are to be delivered separate with the maintenance manuals.

I. See the following checklist for assistance in assembling manual:

Item #	Description	Y, N, or NA
1.	3 ring heavy duty binder with Project name, number and date on cover and project name on spine.	
2.	O&M manual on CD (with label on CD matching label on manual). Electronic copy shall be a PDF file with bookmarks that match the tabs in the hard copy.	
3.	Title Page [including project name, number, address, date awarded, date of substantial completion]	
4.	Second Page Contact List [including architect (if applicable), mechanical engineer, mechanical contractor, and general contractor (if applicable)]	
5.	Table of Contents	
6.	**Section 1 - Summary**	
A.	Warranty	
B.	Mechanical's Sub-contractor List	
C.	Vendor List	
D.	Equipment List	
7.	**Section 2 – Mechanical Equipment**	
A.	Maintenance Schedule (including lubrication list)	

B.	Mechanical Equipment O&M Data (for each piece of equipment submitted) per specifications	
C.	Approved mechanical submittals	
8.	**Section 3 - Controls**	
A.	Sequence of Operation	
B.	Controls diagrams	
C.	Controls Equipment	
9.	**Section 4 – Test and Balance Report**	
A.	Complete Test and Balance Report per specifications	

1.27 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Contractor shall instruct building maintenance personnel in the operation and maintenance of the installed mechanical systems utilizing the Operation and Maintenance Manual when so doing.

B. Minimum instruction periods shall be as follows:
   1. Mechanical - Two hours.
   2. Temperature Control - Two hours.

C. Instruction periods shall occur before final site observation when systems are properly working and before final payment is made.

D. None of these instructional periods shall overlap each other.

E. An additional four hours of instruction will be provided by each contractor, after 60 days of system operation by owner to insure proper system operation and answer questions.

1.28 RECORD DRAWINGS

A. Contractor shall keep an up-to-date set of mechanical and plumbing drawings in his custody showing all changes in red, clearly defined and neatly drafted by him. At the end of construction, he shall turn these drawings over to the Engineer. Record drawings must be completed and submitted prior to final site observation

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

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SECTION 23 05 00

BASIC MECHANICAL AND HVAC MATERIALS AND METHODS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Adjust list below to suit Project.
   2. Piping materials and installation instructions common to most piping systems.
   3. Dielectric fittings.
   4. Mechanical sleeve seals.
   5. Sleeves.
   6. Penetrations
   7. Escutcheons.
   8. Mechanical demolition.
   9. Equipment installation requirements common to equipment sections.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. 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.

F. The following are industry abbreviations for plastic materials:
   1. Retain abbreviations that remain after this Section has been edited.
   2. ABS: Acrylonitrile-butadiene-styrene plastic.
   3. CPVC: Chlorinated polyvinyl chloride plastic.
   4. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Adjust list below to suit Project.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.

B. Welding certificates.

1.05 QUALITY ASSURANCE

A. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

B. All materials, piping, etc. shall be new, and domestically made of the best commercial quality obtainable, consistent with specified materials and for the purpose or function intended unless specifically approved in writing prior to bid.

1.06 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.07 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical 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 mechanical items requiring access that are concealed behind finished surfaces.

PART 2 PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 and 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

A. Refer to individual Division 22 and 23 piping Sections for special joining materials not listed below.

B. 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 thickness or specific material is 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.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
   1. ABS Piping: ASTM D 2235.
   2. CPVC Piping: ASTM F 493.
   3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   4. PVC to ABS Piping Transition: ASTM D 3138.

2.03 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
   1. Coordinate subparagraph and associated subparagraphs below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semiproprietary specifications.
   2. Available Manufacturers:
      a. Capitol Manufacturing Co.

b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.
h. Prior Approved Equal.

2.04 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Coordinate first subparagraph and associated subparagraphs below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semi-proprietary specifications.
   2. Available Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
      e. Linkseal.
      f. Prior Approved Equal.
   3. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   4. Pressure Plates: Carbon steel. Include two for each sealing element.
   5. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.05 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

E. PVC Pipe: ASTM D 1785, Schedule 40.

2.06 PENETRATIONS

A. Floor and wall penetrations of fire rated assemblies shall be protected with FM approved fire stop systems.

2.07 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

2.08 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, non-gaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 MECHANICAL DEMOLITION

A. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 and 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Drawings do not show every offset, or bend that may be required. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors where indicated on drawings and where penetrating will be visible to public.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Edit first subparagraph and associated subparagraph below as required for 2-inch (50-mm) extension above floor.
   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. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   3. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   4. Edit subparagraph below as required for seismic design conditions. Coordinate sleeve requirements with Division 15 Section "Pipe Insulation."
   5. 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:
   6. Edit pipe size range in first two subparagraphs below to suit Project. Confirm that PVC materials are allowed for sleeves by fire authorities having jurisdiction.
   7. 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.

N. 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.

O. 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.

1. 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.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 and 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. 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.

E. 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.

F. 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.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   5. PVC Nonpressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Edit dielectric connection types in two subparagraphs below for each fluid.
   4. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   5. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical 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.

D. Install equipment to allow right of way for piping installed at required slope.

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

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.

PART 2 PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 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: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
   1. Starting codes in first subparagraph below are adequate for most variable-torque loads encountered in HVAC applications; 15 hp is a common breakpoint in rating among manufacturers when Code F and Code G apply. Retain both subparagraphs and options unless Project conditions or equipment characteristics dictate otherwise.
   2. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   3. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   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. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

4. See "Multispeed and Variable-Speed Considerations" Article in the Evaluations for discussion of thermally protected motors. Thermal protection is not usually required for HVAC equipment and energy- or premium-efficient motors specified in this Section. Retain subparagraph below to require the added protection from overheating or if inverter-duty motors are required.
5. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
6. Retain paragraph below only if Project requires severe-duty motors, based on environmental conditions.
7. 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. See Evaluations for a comparison of single-phase motor types.
   2. Permanent-split capacitor.
   3. Split phase.
   4. Capacitor start, inductor run.
   5. 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

(Not Used)

END OF SECTION

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SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This project shall also meet all of the Seismic Bracing requirements and recommendations from FM Global. Submit to FM Global for approval.

C. This specification shall include all components in both Division 22 and 23.

1.02 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Freestanding and restrained spring isolators.
   3. Seismic snubbers.
   4. Restraining braces and cables.

1.03 SCOPE

A. Provide letter of design intent.

B. Provide full set of seismic submittals.

C. Provide final letter of compliance completion.

1.04 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.05 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: Per owner's design standards.
   2. Building Classification Category: As defined in the IBC.
   3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class: As defined in the IBC.
   2. Assigned Seismic Use Group or Building Category: As defined in the IBC.
      a. Retain first three subparagraphs below if these values are not included in the HVAC Vibration-Control and Seismic-Restraint Device Schedule on Drawings. Factors below often vary among supported equipment. However, it is possible to specify maximum values for these factors for various classes of equipment or for all equipment instead of scheduling each piece of equipment.
      b. Component Importance Factor: 1.5.

1.06 SUBMITTALS

A. Product Data: For the following:
   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 seismic-restraint component used.
      a. See Evaluations for a discussion on seismic-restraint capacities and rating services.
      b. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
      c. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Letter of Design intent, stating company, design criteria, compliance with specifications and only exceptions that will apply. Letter shall be stamped and signed by a licensed and qualified professional engineer in this jurisdiction.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 and 23 Sections for equipment mounted outdoors.
   2. 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 has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Seismic- and Wind-Restraint Details:
    a. Design Analysis: To support selection and arrangement of seismic and wind 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 spacing's. 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. Retain first subparagraph below if Project includes equipment mounted outdoors.
    d. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 and 23 Sections for equipment mounted outdoors.
    e. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For professional engineer and testing agency.

G. Field quality-control test reports.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. 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 not available, 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.

E. FM Global review and acceptance.

F. Upon project completion provide a final letter of acceptance for seismic restraints system and installation.

PART 2 PRODUCTS

2.01 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   2. Vibro-acoustics.
   3. ISAT
   4. Mason Industries.
   5. Caddy
   6. Prior approved equal.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene or rubber.

C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or 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.

2.02 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   2. Hilti, Inc.
   3. ISAT
   4. Kinetics Noise Control.
   5. Mason Industries.

6. Vibro-acoustics.
7. Unistrut; Tyco International, Ltd.
8. Prior approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
   1. 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 will be subjected.

C. Snubbers: 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 air gap, and minimum 1/4-inch- thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support 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; and rated in tension, compression, and torsion forces.

E. Restraint Cables: -steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

G. 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.

H. 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.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. 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 E 488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl 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 E 488.

2.03 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for 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 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or 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 will be adequate to carry present and future static and seismic loads within specified loading limits.

3.03 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:
   1. Install seismic snubbers on HVAC 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. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. 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.

G. 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.

H. 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 Division 23 Section "Hydronic Piping" for piping flexible connections.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Leave 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 postconnection 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.
   9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR MECHANICAL AND PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
   1. Adjust list below to suit Project.
   2. Equipment nameplates.
   3. Equipment signs.
   4. Access panel and door markers.
   5. Pipe markers.
   6. Warning tags.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.04 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.05 COORDINATION

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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
   1. Data:
      a. Manufacturer, product name, model number, and serial number.
      b. Capacity, operating and power characteristics, and essential data.
      c. Labels of tested compliances.
   2. Location: Accessible and visible.
   3. Fasteners: As required to mount on equipment.

B. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
   1. Data: Instructions for operation of equipment and for safety procedures.
   2. Engraving: Manufacturer's standard letter style, 1/4” or larger with terms to match equipment identification.
   3. Thickness: 1/8 inch, unless otherwise indicated.
   4. Retain and edit subparagraph above or first subparagraph below.
   5. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

C. Access Panel and Door Markers: 1/16” thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8” center hole for attachment.
   1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.02 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Bradley.
      b. Kolbi.
      c. Prior approved.
   2. Colors: Comply with ASME A13.1, unless otherwise indicated.
   3. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
   4. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
   5. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
   6. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

PART 3 EXECUTION

3.01 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 22 and 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.02 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Edit five subparagraphs below to suit Project.
   2. Fuel-burning units, including boilers, furnaces, heaters, etc.
   3. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   4. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   5. Fans, blowers, primary balancing dampers, and mixing boxes.
   6. Packaged HVAC central-station and zone-type units.

B. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
   1. Identify mechanical equipment with black equipment markers with white lettering.
   2. Letter Size: Minimum 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-fourths the size of principal lettering.
   3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   4. Include signs for the following general categories of equipment:
      a. Edit eight subparagraphs below to suit Project.
      b. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
      c. Fuel-burning units, including boilers, furnaces, heaters, etc.
      d. Pumps, compressors, chillers, condensers, and similar motor-driven units.
      e. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.

f. Fans, blowers, primary balancing dampers, and mixing boxes.
g. Packaged HVAC central-station and zone-type units.
h. Tanks and pressure vessels.
i. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.03 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 nonaccessible 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 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 markers.

C. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.04 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.05 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes TAB to produce design objectives for the following:
   1. Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. HVAC equipment quantitative-performance settings.
   3. Existing systems TAB.
   4. Verifying that automatic control devices are functioning properly.
   5. Reporting results of activities and procedures specified in this Section.

1.03 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

M. TAB: Testing, adjusting, and balancing.

N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

O. Test: A procedure to determine quantitative performance of systems or equipment.

P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.04 SUBMITTALS

A. Qualification Data: Within 15 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
    a. Submittal distribution requirements.

b. The Contract Documents examination report.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

G. Approved TAB agencies:
1. Bonneville Test and Balance.
2. BTC Services.
3. Certified Test and Balance.
4. Environmental Systems Balancing
5. Intermountain Test and Balance.
6. RS Analysis.
7. Tempco
8. Prior approved equal

1.06 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.08 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (NOT APPLICABLE)

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.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

S. 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 strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

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 Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, 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. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" 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 outside-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. Check for proper sealing of air duct system.

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 fan static pressures to determine actual static pressure as follows:
      a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
    a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
6. 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 will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
    a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   3. Measure total system airflow. Adjust to within indicated airflow.
   4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
   5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
      a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
   6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
   7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
   8. Record the final fan performance data.

3.07 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.08 PROCEDURES FOR TESTING DUCT SYSTEMS

A. Duct system will be considered defective if it does not pass initial tests and inspections. The sheet metal contractor shall be responsible to make corrections and repairs as necessary to pass the tests. TAB contractor shall include initial test and 1 follow up test. Any additional follow up tests required due to system not passing shall be performed by the TAB contractor at the Division 22 and 23 contractor's expense.

3.09 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
   2. Air Outlets and Inlets: 0 to minus 10 percent.
   3. Heating-Water Flow Rate: 0 to minus 10 percent.
   4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.11 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: As Work progresses, prepare 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.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Provide final report on standard AABC or NEBB forms.

3.13 INSPECTIONS

A. Initial Inspection:
   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
   2. Randomly check the following for each system:
      a. Measure airflow of at least 10 percent of air outlets.
      b. Measure water flow of at least 5 percent of terminals.
      c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
      d. Measure sound levels at two locations.
      e. Measure space pressure of at least 10 percent of locations.
      f. Verify that balancing devices are marked with final balance position.
      g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:
   1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
   2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.

3. Architect shall randomly select measurements documented in the final report to be rechecked. The 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.
4. If the 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."
5. 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.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 09 00

INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Provide the installation of the controls components furnished with the equipment. This shall include the control wiring, conduit, installation, set up, programming, adjusting, and training of the different control components.

1.03 SUBMITTALS

A. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

B. Qualification Data: For Installer and manufacturer.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Thermostats, sensors, and equipment controllers shall be provided with the equipment. See individual specification sections for specific equipment.

2.02 ACTUATORS

A. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Manufacturers:
      a. Belimo Aircontrols (USA), Inc.
      b. Or equal by.

2.03 DAMPERS

A. Manufacturers:
   1. Air Balance Inc.
   2. Don Park Inc.; Autodamp Div.
   3. TAMCO (T. A. Morrison & Co. Inc.).
   4. United Enertech Corp.
   5. Vent Products Company, Inc.
   6. Ruskin.
   7. Pottorf.
   8. Or equal by.

B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
   1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze or nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   2. Operating Temperature Range: From minus 40 to plus 200 deg F.
   3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
   4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.04 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 26 Section "Voice and Data Communication Cabling."

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.02 INSTALLATION

A. Connect and configure equipment and software to achieve sequence of operation specified.

B. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

C. Install automatic dampers according to Division 22 and 23 Section "Duct Accessories."

D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

E. Install labels and nameplates to identify control components according to Division 22 and 23 Section "Mechanical Identification."

3.03 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

B. Install building wire and cable according to Division 26 Section "Conductors and Cables."

C. Install signal and communication cable according to Division 26 Section "Voice and Data Communication Cabling."
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.05 ADJUSTING

A. Adjust initial set points and schedules.

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 three visits to Project during other than normal occupancy hours for this purpose.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

SECTION 23 11 23

FACILITY NATURAL-GAS PIPING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Valves.
   5. Pressure regulators.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.04 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
   1. Piping and Valves: 100 psig minimum unless otherwise indicated.

1.05 SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   3. Pressure regulators. Indicate pressure ratings and capacities.

B. Welding certificates.

C. Field quality-control reports.

D. Operation and Maintenance Data: For pressure regulators to include in operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. 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.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.08 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.09 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 8 Section "Access Doors and Frames."

PART 2 PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
   5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
      a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.02 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
   2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
   3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
   4. Corrugated stainless-steel tubing with polymer coating.
   5. Operating-Pressure Rating: 0.5 psig.
   6. End Fittings: Zinc-coated steel.
   7. Threaded Ends: Comply with ASME B1.20.1.
   8. Maximum Length: 72 inches.

2.03 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.04 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BrassCraft Manufacturing Company; a Masco company.
      b. Conbraco Industries, Inc.; Apollo Div.
      c. Lyall, R. W. & Company, Inc.
      d. McDonald, A. Y. Mfg. Co.
      e. Perfection Corporation; a subsidiary of American Meter Company.
      f. Prior approved equal..
   2. Body: Bronze, complying with ASTM B 584.
   3. Ball: Chrome-plated brass.
   4. Stem: Bronze; blowout proof.
   5. Seats: Reinforced TFE; blowout proof.
   6. Packing: Separate packnut with adjustable-stem packing threaded ends.
   7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   8. CWP Rating: 600 psig.
   9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.05 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25 current ed.
   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. Vanguard Valves, Inc.
      b. Safe-T-Quake.
      c. Koso
      d. Trembler Tech
      e. Prior approved equal.
   2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   3. Maximum Operating Pressure: 5 psig.
   4. Cast-aluminum body with nickel-plated chrome steel internal parts.
   5. Nitrile-rubber valve washer.
   6. Sight windows for visual indication of valve position.
   7. Threaded end connections complying with ASME B1.20.1.
   8. Wall mounting bracket with bubble level indicator.

2.06 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Pressure Regulators: Comply with ANSI Z21.80.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Actaris.
      b. American Meter Company.
      c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
      d. Invensys.
      e. Richards Industries; Jordan Valve Div.
      f. Prior approved equal.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.03 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 2 Section "Earthwork" for excavating, trenching, and backfilling.
   1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Install fittings for changes in direction and branch connections.

E. 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.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

F. 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.

G. 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.

H. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Division 22 and 23 Section "Meters and Gages."

3.04 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons at penetrations of interior walls, ceilings, and floors.
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
e. Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated or rough-brass finish.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
a. Exception: Tubing passing through partitions or walls does not require striker barriers.
5. Prohibited Locations:
a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 22 and 23 Section "Meters and Gages."

3.05 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.06 PIPING 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. Threaded Joints:
1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. 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. Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.

2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.07 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 and 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Division 22 and 23 Section "Hangers and Supports."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
   5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.08 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.09 LABELING AND IDENTIFYING

A. Comply with requirements in Division 22 and 23 Section "Mechanical Identification" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Division 9 painting Sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
      c. Topcoat: Exterior alkyd enamel (flat).
      d. Color: By owner.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: Quick-drying alkyd metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex (semigloss).
      d. Color: By owner.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

3.13 INDOOR PIPING SCHEDULE

A. Aboveground, branch piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping 2” and larger shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints.

3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
   1. One-piece, bronze ball valve with bronze trim.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, lubricated plug valve.

END OF SECTION

SECTION 23 31 13

METAL DUCTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round and flat-oval ducts and fittings.
   3. Sheet metal materials.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.
   7. Seismic-restraint devices.

B. Related Sections:
   1. Division 22 and 23 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
   2. Division 22 and 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal ducts.

1.03 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 performance requirements and design criteria indicated.
   1. Static-Pressure Classes:
      a. Supply Ducts (except in Mechanical Rooms): 2-inch wg.
      b. Supply Ducts (Upstream from Air Terminal Units): 3-inch wg.
      c. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg.
      d. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg.
      e. Return Ducts (Negative Pressure): 1-inch wg.
      f. Exhaust Ducts (Negative Pressure): 1-inch wg.
   2. Leakage Class:
      a. Round Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg.
      b. Flat-Oval Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg.
      c. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.
      d. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 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 described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
   1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
   2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
   3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.04 SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.

B. Welding certificates.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
   3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 PRODUCTS

2.01 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.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "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."

2.02 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise 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. Lindab Inc.
      b. McGill AirFlow LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Spiral Manufacturing Co., Inc.
      f. Metco.
      g. Prior approved equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter (diameter of the round sides connecting the flat portions of the duct).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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."

2.03 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 A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, 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.

D. 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.

2.04 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.
      e. Prior approved equal.
      f. Maximum Thermal Conductivity:
         1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
         2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. 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.
   3. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   4. Duct insulation shall have a minimum R value = 5 for installation in an unconditioned space, and a minimum R value = 8 for installation outdoors.

B. Insulation Pins and Washers:
   1. 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.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; 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 2-19, "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. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
   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.

2.05 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 according to UL 723; certified by an NRTL.

B. 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 (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. 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.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated 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.

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 ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. 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.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 22 Section "Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.02 SEAM AND JOINT SEALING

A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
   1. For static-pressure classes 1- and 1/2-inch wg, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class C, except as follows:
      a. Ducts that are located directly in zones they serve.

3.03 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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.

3.04 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 22 and 23 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
   2. Test the following systems:
      a. Supply air.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before insulation application.
   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. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.06 DUCT CLEANING

A. Clean new 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 insulation and liner as recommended by duct liner manufacturer. Comply with Division 22 and 23 Section "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-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.

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. 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.

E. 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 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 wash-down 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 removal of surface deposits and debris.

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel:

B. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel.
   2. Stainless-Steel Ducts: Galvanized steel.
   3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

C. Liner:
   1. Supply- and Return-Air Ducts: Fibrous glass, Type I.

D. Double-Wall Duct Interstitial Insulation:
   1. Supply- and Return-Air Ducts: 1 inch thick.

E. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
      c. Velocity 1500 fpm or Higher:
         1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
   2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "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.

F. Branch Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
      a. Rectangular Main to Rectangular Branch: 45-degree entry.
      b. Rectangular Main to Round Branch: Spin in.
   2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
      a. Velocity 1000 fpm or Lower: 90-degree tap.
      b. Velocity 1000 to 1500 fpm: Conical tap.
      c. Velocity 1500 fpm or Higher: 45-degree lateral.

G. Duct Schedule
    1. Rectangular duct with liner:
        a. Low pressure supply and return.
    2. Rectangular duct wrapped with insulation:
        a. Low pressure exhaust and fresh air.
    3. Single wall round with wrapped insulation.
        a. Low pressure supply and return.

END OF SECTION

SECTION 23 33 00

DUCT ACCESSORIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Volume dampers.
   2. High Efficiency Take-Offs.
   3. Motorized control dampers.
   4. Fire dampers.
   5. Combination fire and smoke dampers.
   6. Turning vanes.
   7. Duct-mounting access doors.
   8. Flexible connectors.
   9. Flexible ducts.
   10. Duct accessory hardware.

B. Related Sections include the following:
   1. Division 22 and 23 Section "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Volume dampers.
   2. High Efficiency Take-Offs.
   3. Motorized control dampers.
   4. Fire dampers.
   5. Combination fire and smoke dampers.
   6. Turning vanes.
   7. Duct-mounting access doors.
   8. Flexible connectors.
   9. Flexible ducts.

1.04 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.05 EXTRA MATERIALS

A. 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards–Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. 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.

2.03 VOLUME DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. Clifco
   4. Flexmaster U.S.A., Inc.
   5. Leader
   6. McGill AirFlow Corporation.
   7. METALAIRE, Inc.
   8. Nailor Industries Inc.
   9. Penn Ventilation Company, Inc.
   10. Ruskin Company.

11. Vent Products Company, Inc.
12. Air Rite.
13. Greenheck.
14. Prior approved equal.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
   1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Standard Volume Dampers: Opposed-blade design, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
   1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
   3. Aluminum Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
   4. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   5. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
   6. Blade Axles: Galvanized steel.
   7. Bearings: Oil-impregnated bronze.
   8. Tie Bars and Brackets: Aluminum.
   9. Tie Bars and Brackets: Galvanized steel.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.04 HIGH EFFICIENCY TAKE-OFF

A. Factory-manufactured rectangular-to-round or round-to-round 45 degree leading tap fabricated of 24 ga zinc-coated lockforming quality steel sheets meeting requirements of ASTM A 653, with G-90 coating.

B. One inch wide mounting flange with die formed corner clips, pre-punched mounting holes, and adhesive coated gasket.

C. Manual Volume Damper:
   1. Single blade, 22 ga minimum.
   2. 3/8 inch minimum square rod with brass damper bearings at each end.
   3. Heavy duty locking quadrant on 1-1/2 inch high stand-off mounting bracket attached to side of round duct.

D. Approved Manufacturers:
   1. HETD-L by Daniel Manufacturing.
   2. STO by Flexmaster USA Inc.
   3. HET by Sheet Metal Connectors Inc.
   4. Hercules.
   5. Clifco
   6. Air-Rite.
   7. Prior approved equal.

2.05 MOTORIZED CONTROL DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. CESCO Products.
   4. Duro Dyne Corp.
   5. Greenheck.
   6. McGill AirFlow Corporation.
   7. METALAIRE, Inc.
   8. Nailor Industries Inc.
   9. Penn Ventilation Company, Inc.
   10. Ruskin Company.
   11. Tamco
   12. Vent Products Company, Inc.
   13. Air Rite.
   14. Prior approved equal.

B. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- thick, galvanized-steel damper blades with maximum blade width of 8 inches.
   1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   2. Operating Temperature Range: From minus 40 to plus 200 deg F.
   3. Provide closed-cell neoprene edging.

2.06 FIRE DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. CESCO Products.
   3. Greenheck.
   4. McGill AirFlow Corporation.
   5. METALAIRE, Inc.

6. Nailor Industries Inc.
7. Penn Ventilation Company, Inc.
8. Prefco Products, Inc.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Ward Industries, Inc.
12. Prior approved equal.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, 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. Fusible Links: Replaceable, 165 deg F rated.

2.07 SMOKE AND COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:
1. Air Balance, Inc.
2. CESCO Products.
3. Greenheck.
4. Leader
5. Nailor Industries Inc.
6. Penn Ventilation Company, Inc.
7. Ruskin Company.
8. Prior approved equal.

B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.

C. Fusible Links: Replaceable, 165 deg F rated.

D. Frame and Blades: 0.064-inch- thick, galvanized sheet steel.

E. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

F. Damper Motors: Modulating and two-position action.
   1. Comply with requirements in Division 22 and 23 Section "Motors."
   2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   3. 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.
   4. Outdoor Motors and Motors in Outside-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.
   5. 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.
   6. Electrical Connection: 115 V, single phase, 60 Hz.

2.08 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.
   1. Available Manufacturers:
      a. Ductmate Industries, Inc.
      b. Duro Dyne Corp.
      c. METALAIRE, Inc.
      d. Ward Industries, Inc.
      e. Prior approved equal.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.09 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.
   1. Manufacturers:
      a. American Warming and Ventilating.
      b. CESCO Products.

c. Ductmate Industries, Inc.
d. Flexmaster U.S.A., Inc.
e. Greenheck.
f. McGill AirFlow Corporation.
g. Nailor Industries Inc.
h. Ventfabrics, Inc.
i. Ward Industries, Inc.
j. Air Rite.
k. Prior approved equal.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows:
   a. Less Than 12 Inches Square: Secure with two sash locks.
   b. Up to 18 Inches Square: Two hinges and two sash locks.
   c. Up to 24 by 48 Inches: Three hinges and two compression latches.
   d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

D. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 FLEXIBLE CONNECTORS

A. Manufacturers:
1. Ductmate Industries, Inc.
2. Duro Dyne Corp.
3. Flex-Weld
4. Ventfabrics, Inc.
5. Ward Industries, Inc.
6. Prior approved equal.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 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. Select metal compatible with ducts.

D. 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 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, 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 deg F.

2.11 FLEXIBLE DUCTS

A. Manufacturers:
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.
   3. McGill AirFlow Corporation.
   4. Themaflex.
   5. Quietflex
   6. Prior approved equal.

B. Insulated-Duct Connectors: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 to plus 210 deg F.

2.12 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 APPLICATION AND 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. Provide 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. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
   1. On both sides of duct coils.
   2. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
   3. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
   4. On sides of ducts where adequate clearance is available.

I. Install the following sizes for duct-mounting, rectangular access doors:
   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.

J. Install the following sizes for duct-mounting, round access doors:
   1. One-Hand or Inspection Access: 8 inches in diameter.
   2. Two-Hand Access: 10 inches in diameter.
   3. Head and Hand Access: 12 inches in diameter.
   4. Head and Shoulders Access: 18 inches in diameter.
   5. Body Access: 24 inches in diameter.

K. Label access doors according to Division 22 and 23 Section "Mechanical Identification."

L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

M. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

P. Install duct test holes where indicated and required for testing and balancing purposes.

3.02 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 22 and 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION

SECTION 23 34 23

POWER VENTILATORS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Centrifugal roof ventilators.
   2. In-line centrifugal fans.

1.03 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

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. Delegated-Design Submittal: For unit hangars and 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. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

D. Coordination Drawings: Reflected ceiling plans and other 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. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control reports.

F. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.05 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.06 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.07 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set(s) for each belt-driven unit.

PART 2 PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acme Engineering & Manufacturing Corporation.

2. Aerovent; a division of Twin City Fan Companies, Ltd.
3. Carnes Company.
4. Greenheck Fan Corporation.
5. Loren Cook Company.
6. PennBarry.
7. Prior approved equal

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   5. Fan and motor isolated from exhaust airstream.

E. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: Built-in raised cant and mounting flange.
   2. Overall Height: 18 inches.
   3. Sound Curb: Curb with sound-absorbing insulation.
   4. Pitch Mounting: Manufacture curb for roof slope.
   5. Metal Liner: Galvanized steel.

G. Capacities and Characteristics: See drawings

2.02 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acme Engineering & Manufacturing Corporation.
   2. Carnes Company.
   3. Greenheck Fan Corporation.
   4. Loren Cook Company.
   5. PennBarry.
   6. Prior approved equal

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   3. Companion Flanges: For inlet and outlet duct connections.
   4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

G. Capacities and Characteristics: See drawings

2.03 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 and 23 Section "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 electrical devices and connections specified in Division 26 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.04 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using restrained elastomeric mounts having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 22 and 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 7 Section "Roof Accessories" for installation of roof curbs.

E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

F. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 22 and 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Install units with clearances for service and maintenance.

H. Label units according to requirements specified in Division 22 and 23 Section "Identification for HVAC Piping and Equipment."

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 22 and 23 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

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. Tests and Inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   10. Shut unit down and reconnect automatic temperature-control operators.
   11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 22 and 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:
   1. Division 23 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.03 SUBMITTALS

A. Product Data: For each product indicated, include the following:
   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, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Products: Subject to compliance with requirements, provide one of the products specified.

2.02 GRILLES AND REGISTERS

A. Adjustable Bar Side Wall Supply Grille:
   1. Products:
      a. Carnes; RVEA.
      b. Krueger; 5815.
      c. METALAIRE, Inc., Metal Industries Inc.; 422.
      d. Price Industries; LBMR.
      e. Titus; 1707.
      f. Tuttle & Bailey; VF5.
      g. Or equal by:
         1) A-J Manufacturing Co., Inc.
         2) Anemostat; a Mestek Company.

3) Dayus Register & Grille.
4) Hart & Cooley, Inc.; Hart & Cooley Div.
5) Nailor Industries of Texas Inc.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Adjustable horizontal spaced 1/4 inch apart.
5. Frame: 1 inch wide.

B. Fixed Face Ceiling Return, Exhaust, or Transfer Air Grille:
1. Products:
a. Carnes; RSLA.
b. Krueger; S85H.
c. Price Industries; 535.
d. Titus; 355RL.
e. Tuttle & Bailey; T70D.
f. Or equal by:
1) A-J Manufacturing Co., Inc.
2) Anemostat; a Mestek Company.
3) Dayus Register & Grille.
4) Hart & Cooley, Inc.; Hart & Cooley Div.
5) Nailor Industries of Texas Inc.
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Arrangement: 1/2 inch horizontal blade spacing.
5. Frame: 1-1/4 inches wide.

C. Low Sidewall Return Grilles
1. Finish – Standard white baked enamel.
2. Zero degree deflection.
3. Approved Manufacturers And Models
a. Carnes - RSHA
b. J & J - S-590
c. Krueger - S480H
d. Metalaire - HD-RH
e. Price - 90-L
f. Titus - 30RL or 30 SL
g. Tuttle & Bailey - T110 or equal by
h. Agitair
i. Anemostat
j. Barber Colman
k. Environmental Air Products
l. Air Control Products
m. Nailor

2.03 CEILING DIFFUSER OUTLETS

A. Round Ceiling Diffuser Duct Mounted Exposed:
   1. Manufacturers:
      a. Price RCD or equal by:
         1) Anemostat; a Mestek Company.
         2) Carnes.
         3) Hart & Cooley, Inc.; Hart & Cooley Div.
         4) METALAIRE, Inc.; Metal Industries Inc.
         5) Nailor Industries of Texas Inc.
         6) Titus.
         7) Tuttle & Bailey.
         8) Prior approved equal.
   2. Material: Heavy gauge spun steel.
   3. Finish: Baked enamel, color selected by Architect.
   4. Face Style: Three cone.
   5. Pattern: Two position horizontal.

B. Rectangular and Square Ceiling Diffusers:
   1. Products:
      a. Carnes.
      b. Krueger.
      c. METALAIRE, Inc., Metal Industries Inc.
      d. Price Industries; SPD or equal by.
      e. Titus.
      f. Tuttle & Bailey.
      g. A-J Manufacturing Co., Inc.
      h. Anemostat; a Mestek Company.
      i. Hart & Cooley, Inc.; Hart & Cooley Div.
      j. Nailor Industries of Texas Inc.
      k. Prior approved equal.
   2. Material: Steel.
   3. Finish: Baked enamel, white.

2.04 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles 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, registers, and grilles are to be 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, registers, and grilles 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 practicable. For units installed in lay-in ceiling panels, provide lay-in ceiling module. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and 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 diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 37 14

LOUVERS AND VENTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Fixed, extruded-aluminum louvers.

1.03 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 axes of the blades are horizontal.

C. Vertical Louver: Louver with vertical blades; i.e., the axes 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. Storm-Resistant Louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.04 PERFORMANCE REQUIREMENTS

A. 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 according to AMCA 500-L.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated.
   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, flashing, sealant, and other means of preventing water intrusion.
   2. Show mullion profiles and locations.

3. Wiring Diagrams: For power, signal, and control wiring for motorized adjustable louvers.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Samples for Verification: For each type of metal finish required.

E. Product Test Reports: Based on evaluation of comprehensive tests performed according to 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.

1.06 QUALITY ASSURANCE

A. Source Limitations: Obtain louvers and vents from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

B. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."
3. AWS D1.6, "Structural Welding Code - Stainless Steel."

C. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

D. UL and NEMA Compliance: Provide motors and related components for motor-operated louvers that are listed and labeled by UL and comply with applicable NEMA standards.

1.07 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Aluminum Castings: ASTM B 26/B 26M, Alloy 319.

D. 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 galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.

4. For fastening stainless steel, use 300 series stainless-steel fasteners.
5. For color-finished louvers, use fasteners with heads that match color of louvers.

E. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.02 FABRICATION, GENERAL

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Include supports, anchorages, and accessories required for complete assembly.

C. Provide subsills made of same material as louvers or extended sills for recessed louvers.

2.03 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Nondrainable-Blade Louver:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ruskin Company; Tomkins PLC. Model ELF811 or equa by.
   b. Airolite Company, LLC (The).
   c. American Warming and Ventilating, Inc.; a Mestek company.
   d. Arrow United Industries; a division of Mestek, Inc.
   e. Carnes Company, Inc.
   f. Cesco Products; a division of Mestek, Inc.
   g. Greenheck Fan Corporation.
   h. NCA Manufacturing, Inc.
   i. Pottrof
   j. United Enertec
   k. Prior approved equal.
2. Fabrication: Continuous blade style.
   a. Frame:
      1) Frame Depth: 4 inches (102mm).
      2) Material: Extruded aluminum, Alloy 6063-T5.
      3) Wall Thickness: 0.125 inch (3.2mm), nominal.
   b. Blades:
      1) Style: Horizontal “K”.
      2) Material: Formed aluminum, Alloy 6063-T5.
      3) Wall Thickness: 0.125 inch (3.2 mm), nominal.

4) Angle: 45 degrees.
5) Centers: 4-1/2 inches (114 mm), nominal.
6) Continuous Blade Style – Design incorporates visible mullions or frames at the perimeter of the louver only. Rear-mounted hidden blade supports are utilized at section joints and at intermediate locations as needed. Louver blade sightlines are not interrupted at section joints or blade support locations. The rear-mounted blade support depth varies depending on louver height and the design windload.
7)

c. Assembly:
1) Factory assembled louver components. Mechanically fastened construction.

B. Performance Data:
1. Performance Ratings:
a. Based on testing 48 inch by 48 inch (1219 mm by 1219 mm) size unit in accordance with AMCA 500.
2. Free Area: 44 percent, nominal.
3. Maximum Recommended Air Flow through Free Area: 707 feet per minute (214 m/min).
4. Air Flow: 5027 cubic feet per minute (142 cu. m/min).
5. Maximum Pressure Drop (Intake): .06 inches w.g. (14.9 Pa).
6. Water Penetration: Maximum of 0.01 ounces per square foot (3.1 g/sm) of free area at an air flow of 707 feet per minute (214 m/min) free area velocity when tested for 15 minutes.

C. Design Load: Incorporate structural supports required to withstand wind load of:
1. 20 lb/sf (0.96 kPa).
2. Per Code.
3. Louvers shall be factory engineered to withstand the specified seismic loads.
a. Minimum design loads shall be calculated to comply with ASCE – 7, or local requirements of Authority Having Jurisdiction.

2.04 ACCESSORIES

A. Aluminum Insulated Blank-Off Panels: 1 inch (25 mm), aluminum skin, insulated core, factory installed with removable screws and neoprene gaskets.

B. Hinged Frame: Continuous piano hinge attached to angle subframe.

C. Hinged Frame: Continuous piano hinge attached to channel subframe.

D. Bird Screen:
1. Aluminum: Aluminum, 3/4 inch by 0.051 inch (19 mm by 1.3 mm), expanded, flattened.
2. Aluminum: Aluminum, 5/8 inch by 0.040 inch (16 mm by 1 mm), expanded, flattened.

3. Aluminum: Aluminum, 1/2 inch mesh by 0.063 inch (13 mm mesh by 1.6 mm), intercrimp.
4. Steel: Galvanized steel, 1/2 inch mesh by 19 gage (13 mm mesh by 1.1 mm), intercrimp.
5. Frame: Removable, rewireable.

2.05 FINISHES

A. Kynar:
1. Coating shall conform to AAMA 2605. Apply coating following cleaning and pretreatment. Cleaning: AA-C12C42R1X.
2. Standard 2-coat.
3. Pearledize 70 (2-coat mica).

B. 50 percent Floropolymer-Based Painted Finishes:
1. Coating shall conform to AAMA 2604, sections 4.2 and 4.3. Apply coating following cleaning and pretreatment. Cleaning: AA-C12C42R1X.
2. Baked Enamel.
3. Pearledize 50 (2-coat mica).

C. Color for Kynar Finish:
1. Color: Custom. Refer to Drawings.

D. Anodized Finishes:
1. Class 2 Clear Anodized.
a. Comply with Aluminum Association AA-C22A41. Clear anodized finish 215-R1.
b. Apply finish following chemical etching and pretreatment.
c. Minimum Thickness: 0.7 mils (0.018 mm), 60 minute anodizing process.

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.

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 and vents 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. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

F. Protect unpainted galvanized and nonferrous-metal surfaces that will be 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.

G. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 7 Section "Joint Sealants" for sealants applied during louver installation.

3.04 ADJUSTING AND CLEANING

A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.

B. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

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 and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, 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 23 54 00

FURNACES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Gas-fired, condensing furnaces and accessories complete with controls.
   2. Air filters.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each of the following:
   1. Furnace.
   2. Air filter.
   3. Refrigeration components.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each furnace to include in operation, and maintenance manuals for each of the following:
   1. Furnace and accessories complete with controls.
   2. Refrigeration components.

D. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
   1. Warranty Period, Commencing on Date of Substantial Completion:
      a. Furnace Heat Exchanger: 10 years.
      b. Integrated Ignition and Blower Control Circuit Board: Five years.
      c. Draft-Inducer Motor: Five years.
      d. Refrigeration Compressors: 10 years.
      e. Evaporator and Condenser Coils: Five years.

1.07 EXTRA MATERIALS

A. 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. Disposable Air Filters: Furnish two complete sets.

PART 2 PRODUCTS

2.01 GAS-FIRED FURNACES, CONDENSING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier MVB or equal by.
   2. Trane.
   3. York.
   4. Daikin
   5. Lennox
   6. Prior approved equal.

B. General Requirements for Gas-Fired, Condensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.

C. Cabinet: Steel.
   1. Cabinet interior around heat exchanger shall be factory-installed insulation.
   2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
   3. Factory paint external cabinets in manufacturer's standard color.

D. Fan: Centrifugal, factory balanced, resilient mounted, direct drive, variable speed.
   1. Special Motor Features: Variable speed, premium efficiency, as defined in Division 22 and 23 Section "Motors," and with internal thermal protection and permanent lubrication.
   2. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
   3. Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

E. Type of Gas: Natural.

F. AFUE: 90 percent.

G. Heat Exchanger:
   1. Primary: Aluminized steel.

H. Burner:
   1. Gas Valve: 100 percent safety two-stage main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
   2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.

I. Controls:
   1. Provide with 7 day programmable thermostat with auto change over to control, each furnace and associated condensing unit and cooling coil.

J. Gas-Burner Safety Controls:
   1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
   2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
   3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

K. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

L. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories.

M. Accessories:
   1. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through outside wall or roof.
   2. Plastic Vent Materials.
      a. CPVC Plastic, Schedule 40 Pipe: ASTM F 441/F 441M.
         1) CPVC Plastic, Schedule 40 Fittings: ASTM F 438, socket type.
         2) CPVC Solvent Cement: ASTM F 493.

b. PVC Plastic, Schedule 40 Pipe: ASTM D 1785.
   1) PVC Plastic, Schedule 40 Fittings: ASTM D 2466, socket type.
   2) PVC Solvent Cement: ASTM D 2564.

N. Capacities and Characteristics: See drawings.

2.02 AIR FILTERS

A. Disposable Filters: 1-inch- thick, disposable, fiberglass type in sheet metal frame.

2.03 REFRIGERATION COMPONENTS

A. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace. Include condensate drain pan with accessible drain outlet.
   1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.

B. Refrigerant Piping: Comply with requirements in Division 23 Section "Refrigerant Piping."

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 factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.

B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
   1. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.

C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
   1. Anchor furnace to substrate to resist code-required seismic acceleration.

D. Controls: Install thermostats and humidistats at mounting height of 60 inches above floor.

E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

3.03 CONNECTIONS

A. Gas piping installation requirements are specified in Division 22 Section "Fuel Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Division 23 Section "Breechings, Chimneys, and Stacks."

D. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
   1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
   2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
   3. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
      a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
      b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
      c. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   4. Slope pipe vent back to furnace or to outside terminal.

E. Connect ducts to furnace with flexible connector. Comply with requirements in Division 22 and 23 Section "Duct Accessories."

F. Connect refrigerant piping to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.
   1. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
   2. 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.
   3. 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.

G. Comply with requirements in Division 22 and 23 Section "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.04 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Perform electrical test and visual and mechanical inspection.
   2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
   5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

3.05 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for physical damage to unit casings.
   2. Verify that access doors move freely and are weathertight.
   3. Clean units and inspect for construction debris.
   4. Verify that all bolts and screws are tight.
   5. Adjust vibration isolation and flexible connections.
   6. Verify that controls are connected and operational.

B. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.

D. Measure and record airflows.

E. Verify proper operation of capacity control device.

F. After startup and performance test, lubricate bearings.

3.06 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

3.07 CLEANING

A. After completing installation, clean furnaces internally according to manufacturer's written instructions.

B. Install new filters in each furnace within 14 days after Substantial Completion.

3.08 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

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SECTION 23 52 16

CONDENSING UNITS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes air-cooled condensing units.

1.03 SUBMITTALS

A. Product Data: For each condensing unit, include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.

B. Manufacturer Seismic Qualification Certification: Submit certification that condensing units, accessories, and components will withstand seismic forces defined in Division 22 and 23 Section "Mechanical Vibration and Seismic Controls." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      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. 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. Field quality-control test reports.

D. Operation and Maintenance Data: For condensing units to include in operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of condensing units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
   1. Units shall be designed to operate with HCFC-free refrigerants.

D. ASME Compliance: Fabricate and label water-cooled condensing units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

C. Coordinate location of piping and electrical rough-ins.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Compressor failure.
      b. Condenser coil leak.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 CONDENSING UNITS, AIR COOLED, 1 TO 5 TONS

A. Manufacturers:
   1. Carrier Corporation; Carrier Air Conditioning Div.
   2. Lennox Industries Inc.
   3. Daikin
   4. Rheem Manufacturing Air Conditioning Div.
   5. Trane Co. (The); Worldwide Applied Systems Group.
   6. York International Corp.
   7. Prior approved equal

B. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.

C. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
   1. Motor: Single speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
   3. Accumulator: Suction tube.
   4. Refrigerant Charge: R-410A.

D. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.

E. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.

F. Accessories:
   1. Crankcase heater.
   2. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
   3. Electronic programmable thermostat to control condensing unit and evaporator fan.
   4. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
   5. Filter-dryer.
   6. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
   7. Liquid-line solenoid.
   8. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F.
   9. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
   10. Thermostatic expansion valve.
   11. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.

G. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

2.03 CONDENSING UNITS, AIR COOLED, 6 TO 120 TONS

A. Manufacturers:
   1. Carrier Corporation; Carrier Air Conditioning Div.
   2. Lennox Industries Inc.
   3. Daikin
   4. Rheem Manufacturing Air Conditioning Div.
   5. Trane Co. (The); Worldwide Applied Systems Group.
   6. York International Corp.

7. Prior approved equal

B. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

C. Compressor: Hermetic or semihermetic compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
   1. Capacity Control: Variable Speed Compressor .
   2. Refrigerant Charge: R-410A or R-32.

D. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.

E. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
   1. Permanently lubricated ball-bearing motors.
   2. Separate motor for each fan.
   3. Dynamically and statically balanced fan assemblies.

F. Operating and safety controls include the following:
   1. Manual-reset, high-pressure cutout switches.
   2. Automatic-reset, low-pressure cutout switches.
   3. Low oil pressure cutout switch.
   4. Compressor-winding thermostat cutout switch.
   5. Three-leg, compressor-overload protection.
   6. Control transformer.
   7. Magnetic contactors for compressor and condenser fan motors.
   8. Timer to prevent excessive compressor cycling.

G. Accessories:
   1. Electronic programmable thermostat to control condensing unit and evaporator fan.
   2. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F.
   3. Gage Panel: Package with refrigerant circuit suction and discharge gages.
   4. Part-winding-start timing relay, circuit breakers, and contactors.

H. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
   1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
   2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
   3. Gasketed control panel door.
   4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.

5. Condenser coil hail guard to protect coil from physical damage.

2.04 MOTORS

A. General requirements for motors are specified in Division 22 and 23 Section "Motors."
   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: Electrical devices and connections are specified in Division 26 Sections.

2.05 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate condensing units according to ARI 210/240.
   1. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
   2. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

B. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

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 condensing units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where condensing units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

B. Install condensing units on concrete base. Concrete base is specified in Division 22 and 23 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

C. Concrete Bases:
   1. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
   2. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

D. Install roof-mounting units on equipment supports specified in Division 7.

E. Vibration Isolation: Mount condensing units on rubber pads with a minimum deflection of 1/4 inch. Vibration isolation devices and installation requirements are specified in Division 22 and 23 Section "Mechanical Vibration and Seismic Controls."

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect refrigerant piping to air-cooled condensing units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 22 and 23 Section "Refrigerant Piping."

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Perform electrical test and visual and mechanical inspection.
   2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   5. Verify proper airflow over coils.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

C. Remove and replace malfunctioning condensing units and retest as specified above.

3.05 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for physical damage to unit casing.
   2. Verify that access doors move freely and are weathertight.
   3. Clean units and inspect for construction debris.
   4. Verify that all bolts and screws are tight.
   5. Adjust vibration isolation and flexible connections.
   6. Verify that controls are connected and operational.

B. Lubricate bearings on fans.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Adjust fan belts to proper alignment and tension.

E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

F. Measure and record airflow over coils.

G. Verify proper operation of condenser capacity control device.

H. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

I. After startup and performance test, lubricate bearings and adjust belt tension.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Division 1 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION

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SECTION 23 73 39

DIRECT-FIRED H&V UNITS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes direct-fired H&V units.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:
   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   2. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
   4. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Roof-mounted units and roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to curb.
   2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and Maintenance Data: For direct-fired H&V units to include in operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of direct-fired H&V units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate size, location, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

C. Coordinate size, location and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.
   1. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 22 and 23 Section "Mechanical Vibration and Seismic Controls."

1.06 EXTRA MATERIALS

A. 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. Filters: One set(s) for each unit.
   2. Fan Belts: One set(s) for each unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ARES; Mars Air Products.
   2. Cambridge Engineering, Inc.
   3. Captive-Air Systems, Inc.
   4. CES Group; Ventrol Air Handling Systems, Inc.
   5. Greenheck.
   6. Hastings Industries; Division of Eric, Inc.
   7. Modine Mfg. Co.; Commercial HVAC&R Division.
   8. Reznor-Thomas & Betts Corporation; Mechanical Products Division.
   9. Sterling Gas; Mestek, Inc.
   10. Trane Company (The); Unitary Products Group.
   11. Weather-Rite, Inc.
   12. Prior approved equal.

2.02 PACKAGED UNITS

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and direct-fired gas furnace to be installed outside and inside the building, see drawings.

2.03 CABINET

A. Cabinet: Double-wall galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation.

B. Access Panels: Piano hinged with cam-lock fasteners for furnace and fan motor assemblies on both sides of unit.

C. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit.
   1. Thickness: 1 inch.
   2. Insulation Adhesive: Comply with ASTM C 916, Type I.
   3. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

D. Finish: Heat-resistant, baked enamel.

E. Discharge: Horizontal-pattern, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.

2.04 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings.

B. Motor: Open dripproof, variable-speed motor.

C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, spring isolators.

2.05 OUTDOOR-AIR INTAKE

A. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen, and finish to match cabinet; and sized to supply maximum 100 percent outdoor air.

2.06 AIR FILTERS

A. Comply with NFPA 90A.

B. Disposable Panel Filters: 2-inch-thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.
   1. Media: Interlaced glass or polyester fibers.
   2. Frame: Galvanized steel.

2.07 DAMPERS

A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. of damper area, at differential pressure of 2-inch wg.

B. Fan-Discharge Dampers: Galvanized-steel, opposed-blade damper.

C. Balancing/Bypass Dampers: Galvanized-steel, opposed-blade damper.

D. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.08 DIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.4, "Direct Gas-Fired Make-Up Air Heaters"; ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."

B. Inside Unit External Housing: Steel cabinet with integral support inserts.

C. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.
   1. External Casing and Cabinet Finish: Baked enamel over corrosion-resistant-treated surface in color to match fan section.

D. Burners: Cast-iron burner with stainless-steel mixing plates.
   1. Control Valve: Modulating with minimum turndown ratio of 25:1.
   2. Fuel: Natural gas.
   3. Pilot: Electrically ignited by hot-surface ceramic igniter.

E. Safety Controls:
   1. Gas Manifold: Safety switches and controls to comply with ANSI standards and IRI.
   2. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
   3. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
   4. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
   5. Gas Train: Redundant, automatic main gas valves, electric pilot valve, electronic-modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches to comply with IRI requirements.

6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
7. Control Transformer: Integrally mounted 24-V ac.

2.09 CONTROLS

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted remote panel, with engraved plastic cover, and the following lights and switches:
   1. On-off-auto switch.
   2. Summer-winter switch. Provide custom programming for summer and winter modes at the unit controller.
   3. Supply-fan operation indicating light.
   4. Heating operation indicating light.
   5. Damper position potentiometer.
   6. Thermostat.
   7. Cooling operation indicating light.
   8. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
   9. Safety-lockout indicating light.

C. Refer to Division 22 and 23 Section "HVAC Instrumentation and Controls" for control equipment and sequence of operation.

D. Control Devices:
   1. Remote Thermostat: Adjustable room thermostat with temperature readout.
   2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
   3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature.
   5. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
   6. Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
   7. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

8. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.

E. Fan Control: Interlock fan to start with exhaust fan(s).
   1. Program summer mode to operate at high speed and winter mode to operate at low speed. Coordinate with TAB contractor to determine the speeds that correspond to the design airflows in each condition.

F. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

G. Temperature Control: Operates gas valve to maintain supply-air or room temperature in heating mode.

2.10 MOTORS

A. Comply with requirements in Division 22 and 23 Section "Motors."

2.11 CAPACITIES AND CHARACTERISTICS – SEE DRAWINGS

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 installation of direct-fired H&V units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

B. Install roof curb on roof structure, according to ARI Guideline B. Install and secure direct-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.

C. Install suspended units from spring hangers with minimum 1-inch static deflection; refer to Division 22 and 23 Section "Mechanical Vibration and Seismic Controls."

D. Install floor-mounted units on restrained, spring isolators with minimum 1-inch static deflection; refer to Division 22 and 23 Section "Mechanical Vibration and Seismic Controls."

E. Install controls and equipment shipped by manufacturer for field installation with direct-fired H&V units.

3.03 CONNECTIONS

A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
   1. Gas Piping: Comply with requirements in Division 22 and 23 Section "Fuel Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
   2. Drain: Comply with requirements in Division 22 and 23 Section "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to evaporative cooling units.

B. Duct Connections: Duct installation requirements are specified in Division 22 and 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to direct-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 22 and 23 Section "Duct Accessories."

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for visible damage to furnace combustion chamber.
   2. Inspect casing insulation for integrity, moisture content, and adhesion.
   3. Verify that clearances have been provided for servicing.
   4. Verify that controls are connected and operable.
   5. Verify that filters are installed.
   6. Purge gas line.
   7. Inspect and adjust vibration isolators and seismic restraints.
   8. Verify bearing lubrication.
   9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   10. Adjust fan belts to proper alignment and tension.
   11. Start unit according to manufacturer's written instructions.
   12. Complete startup sheets and attach copy with Contractor's startup report.
   13. Inspect and record performance of interlocks and protective devices; verify sequences.
   14. Operate unit for run-in period recommended by manufacturer.
   15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
       a. Measure gas pressure on manifold.
       b. Measure combustion-air temperature at inlet to combustion chamber.

c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
19. Start evaporative cooler system and measure and record the following:
    a. Leaving-air, dry- and wet-bulb temperatures.
    b. Entering-air, dry- and wet-bulb temperatures.
20. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
21. Measure and record airflow. Plot fan volumes on fan curve.
22. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
    a. High-limit heat.
    b. Alarms.
23. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

3.05 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. 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 during other-than-normal occupancy hours for this purpose.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain direct-fired H&V units. Refer to Division 1 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONING UNITS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. Units shall be designed to operate with HCFC-free refrigerants.

1.05 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 7 Section "Roof Accessories."

1.06 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: Five years from date of Substantial Completion.

1.07 EXTRA MATERIALS

A. 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. Filters: One set of filters for each unit.
   2. Fan Belts: One set of belts for each unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Air Conditioning; Div. of Carrier Corporation.
   2. Fujitsu.
   3. Mitsubishi.
   4. LG
   5. Daikin
   6. Trane Company (The); Unitary Products Group.
   7. Prior approved equal.

2.02 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

D. Fan: Direct drive, centrifugal fan.

E. Fan Motors: Comply with requirements in Division 22 and 23 Section "Motors."
   1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

F. Filters: Permanent, cleanable.

2.03 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. 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.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   1. Compressor Type: Scroll.
   2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   3. Refrigerant Charge: R-410A or R-32.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.

G. Low Ambient Kit: Permits operation down to 0 deg F.

H. Mounting Base: Polyethylene.

2.04 ACCESSORIES

A. Control equipment and sequence of operation are specified in Division 22 and 23 Sections "HVAC Instrumentation and Controls" and "Sequence of Operation."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.

3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection, including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. 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.

E. Additional Monitoring:
1. Monitor constant and variable motor loads.
2. Monitor variable frequency drive operation.
3. Monitor economizer cycle.
4. Monitor cooling load.
5. Monitor air distribution static pressure and ventilation air volumes.

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. Install ground-mounting, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install ground-mounting, compressor-condenser components on polyethylene mounting base.

E. Install roof-mounting compressor-condenser components on equipment supports specified in Division 7 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Install seismic restraints.

G. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 22 and 23 Section "Mechanical Vibration Controls and Seismic Restraints."

H. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   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.

C. Remove and replace malfunctioning units and retest as specified above.

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.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 1 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION

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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies general requirements for electrical work. Detailed requirements for specific electrical items are specified in other sections but are subject to the general requirements of this section. The electrical drawings and schedules included in this project manual are functional in nature and do not specify exact locations of equipment or equipment terminations.

B. Definitions:

1. Elementary or Schematic Diagram:
    a. A schematic (elementary) diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
2. One-Line Diagram:
    a. A one-line diagram shows by means of single lines and graphical symbols the course of an electrical circuit or system of circuits and the components, devices or parts used therein. Physical relationships are usually disregarded.
3. Block Diagram:
    a. A block diagram is a diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
4. Wiring Diagram or Connection System:
    a. A wiring or connection diagram includes all of the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. This diagram shall be (a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or (b) a panel layout diagram showing the physical location of devices plus the elementary diagram.
5. Interconnection Diagram:
    a. Interconnection diagrams shall show all external connections between terminals of equipment and outside points, such as motors and auxiliary devices. References shall be shown to all connection diagrams which interface to the interconnection diagrams. Interconnection diagrams shall be of the continuous line type. Bundled wires shall be shown as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
        1) Each wire identification as actually installed shall be shown. The wire identification for each end of the same wire shall be identical. All devices and equipment shall be identified. Terminal blocks shall be shown as actually installed and identified in the equipment complete with individual terminal identification.

2) All jumpers, shielding and grounding termination details not shown on the equipment connection diagrams shall be shown on the interconnection diagrams. Wires or jumpers shown on the equipment connection diagrams shall not be shown again on the interconnection diagram. Signal and DC circuit polarities and wire pairs shall be shown. Spare wires and cables shall be shown.

6. Arrangement, Layout, Or Outline Drawings:
   a. An arrangement, layout, or outline drawing is one which shows the physical space and mounting requirements of a piece of equipment. It may also indicate ventilation requirements and space provided for connections or the location to which connections are to be made.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NECA-1	National Electrical Contractors Association – Standard Practices for Good Workmanship in Electrical Contracting
NFPA	National Fire Protection Association
NFPA-70	National Electrical Code (NEC)
NFPA-70E	National Electrical Safety Code (NESC)
ACI 318	Building Code Requirements for Structural Concrete

B. Identification of Listed Products:
   1. List electrical equipment and materials for the purpose for which they are to be used, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Electrical Testing Laboratories (ETL). Independent testing laboratory shall be acceptable to the inspection authority having jurisdiction.
   2. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority, to undergo inspection at the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

C. Factory Tests:
   1. Where specified in the individual product specification section, perform factory tests at the place of fabrication and performed on completion of manufacture or assembly. Include the costs of factory tests in the contract price.

1.03 SUBMITTALS

A. Provide submittals in accordance with Section 01 33 00. Each specification will identify any additional requirements beyond those identified in 01 33 00.

1.04 PROJECT/SITE CONDITIONS

A. General: Unless otherwise specified, size and derate equipment and materials for the ambient conditions specified in Section 01 11 80, but not less than an ambient temperature of 80 degrees C at an elevation ranging from sea level to 5000 feet without exceeding the manufacturer's stated tolerances.

B. Corrosive Areas:
   1. Corrosive areas are specified in Section 01 61 45

C. Hazardous (Classified) Areas:
   1. The following areas are designated as hazardous (classified) in accordance with the NEC:

Area	Hazardous Classification
None	

D. Enclosure Material and Rating
   1. Table A specifies the electrical enclosure material and rating for the location and application.

TABLE A

Location	Electrical Enclosure Material and NEMA Rating
Indoor: Architecturally Finished Area	NEMA 1: Mild steel
Indoor: Electrical Room	NEMA 1: Mild steel
Indoor: Process Areas	NEMA 4X: Stainless Steel
Indoor: Corrosive Area	NEMA 4X: Stainless Steel
Outdoor: Corrosive Area	NEMA 4X: Stainless Steel
Outdoor: Non-Corrosive Areas	NEMA 4X: Stainless Steel
Corrosive Area (Hypochlorite)	NEMA 4X: Fiberglass
Corrosive Area (Polymer)	NEMA 4X: Stainless Steel
Hazardous Area: Class I Division 2	NEMA 4X: Stainless Steel
Hazardous Area: Class I Division 1	NEMA 7: Galvanized Malleable Iron or Aluminum

E. Support Material and Rating
   1. Table B specifies the support material for mounting and supporting equipment and rating for the location and application.

TABLE B

Location	Framing Channel	Threaded Rod, Hardware, & Fittings
Indoor, Architecturally finished Area	Steel, HDG	Steel, HDG
Indoor, Electrical Room	Steel, HDG	Steel, HDG
Indoor, Process Areas	Steel, HDG	Steel, HDG
Corrosive Area (hypochlorite area)	Fiberglass	Fiberglass
Corrosive Area (polymer area)	Stainless Steel	Stainless Steel
Indoor, Corrosive Area (general)	Stainless Steel	Stainless Steel
Outdoor, Corrosive Area (general)	Stainless Steel	Stainless Steel
Outdoor Areas, Non-corrosive	HDG	HDG

HDG = Hot Dip Galvanized Finish

PVC = PVC Coated

F. Seismic:
   1. Design and install electrical equipment, supports, and anchorage in accordance with the seismic design requirements specified in Section 01 73 24.
   2. Special Seismic Certification required for Electrical MCC's, Switchboards, Panelboards, Transformers, Generators, Control Panels, and Fire Alarm System see specification section 01 73 24 for requirements.

1.05 STORAGE OF MATERIALS AND EQUIPMENT

A. Store materials and equipment as specified in Section 01 66 00-2.05. Seal indoor designated equipment and materials with plastic wrap and store.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. General:
   1. Provide equipment and materials new and free from defects. Provide all material and equipment of the same or a similar type from the same manufacturer throughout the work. Use standard production materials wherever possible.

B. Equipment Finish:
   1. Unless otherwise specified, manufacturer will paint electrical equipment as specified in Section 09 90 00.

C. Galvanizing:
   1. Where specified, provide galvanizing e in accordance with Section 05 05 13.13.

2.02 NAMEPLATES

A. Nameplates shall be made from laminated phenolic plastic.
   1. Nominal size: 3/4 inch high by 2 inches long.
   2. Black backgrounds with 3/16-inch white letters.

3. Fastened using self-tapping stainless steel screws. Nameplate adhesives will not be permitted on the outside of enclosures.
4. Abbreviations shall be submitted to the Construction Manager prior to manufacture because of space limitations.

2.03 PRODUCT DATA

A. The following information and product data specified under individual specification sections shall be provided in accordance with Section 01 33 00.
   1. Applicable operation and maintenance information on an item-by-item basis in accordance with Section 01 78 23. Provide operation and maintenance information at the time of equipment, device, or material site delivery, or at a certain stage of project completion as required by Section 01 78 23, whichever is the earlier. Reduce full-size drawings to 11 x 17 inches.
   2. Provide test results for motors and electrical systems on the forms specified in Section 26 08 00. Maintain a file of the original test. Prior to acceptance of work, provide the resulting file to the Construction Manager.
   3. Description of functional checkout procedures specified under paragraph 3.02 Pre-Functional Test Checkout provided 14 days prior to performing functional checkout tests.
   4. Record documents specified in Section 01 78 39 and paragraph 3.03.

PART 3 EXECUTION

3.01 GENERAL

A. Construction:
   1. The work under Division 26 shall be performed in accordance with these specifications.
   2. Refer to the National Electrical Contractors Association's (NECA) National Electrical Installation Standards (NEIS) for Standard Practices for Good Workmanship in Electrical Contracting (NECA-1) as a minimum baseline of quality and workmanship for installing electrical products and systems that defines what is meant by "neat and workmanlike" as required by the National Electrical Code Section 110-12. Specified requirements supersede NECA practices.
   3. Electrical layout drawings are diagrammatic, unless otherwise detailed or dimensioned. The Contractor shall coordinate the location of electrical material or equipment with the work.
   4. Major electrical openings may compromise the structural integrity of the slab and wall elements. Major electrical openings are defined as openings or penetrations greater than two times the wall thickness in any dimension, and include duct bank transitions into a building through structural elements. Major electrical openings shall be constructed according to standard details on the drawings, up to an opening dimension of three feet. For opening dimensions greater than three feet, construct walls and slabs as specifically detailed on the drawings for that case. Major electrical openings proposed by the Contractor shall be submitted to the Structural Engineer of Record for the project for review.
   5. Minor changes in location of electrical material or equipment made prior to installation shall be made at no cost to the Owner.

B. Housekeeping:
   1. Protect electrical equipment from dust, water and damage. Wipe motor control centers, switchgear, and buses free of dust and dirt, keep dry, and vacuum on the inside within 30 days of acceptance of the work.
   2. Before final acceptance, the touch up any scratches on equipment as specified in Section 09 90 00-3.03 Special Requirements.
   3. Protect electrical equipment temporarily exposed to weather, debris, liquids, or damage during construction as specified in Section 01 66 00-2.06.

C. Electrical Equipment Labeling:
   1. Provide electrical equipment with field marked signs and labeling to warn qualified persons of the potential electric arc flash hazards per NEC Article 110.16 Flash Protection.
   2. Provide electrical equipment with NFPA 70E labels installed stating the results of the Arc Flash analysis specified in Section 26 05 74 Short Circuit and Protective Device Coordination Study Report.
   3. Provide electrical distribution equipment and utilization equipment with field labels to identify the power source and the load as specified. Refer to NEC Article 110.22 for Identification of Disconnecting Means installation criteria. Specific information is required such as the equipment tag number and equipment description of both the power source and the load equipment.

D. Motor Connections
   1. Verify that the motors are purchased with the correct size motor termination boxes for the circuit content specified as shown on the power single line diagrams or submit custom fabrication drawing indicating proposed motor termination box material, size, gasket, termination kit, grounding terminal, motor lead connection method, and motor terminal box connection/support system. Verify the motor termination box location prior to raceway rough-in.

3.02 TESTING

A. Provide testing in accordance with Section 26 08 00

3.03 RECORD DOCUMENTS

A. Maintain and annotate contract documents and during construction, including the record drawings specified in Section 01 78 39 and the following additional schedules, lists, and drawings:
   1. Cable Schedule (Section 26 05 19)
   2. Raceway Schedule (Section 26 05 33)
   3. Interconnection Diagrams (Section 26 05 00)
   4. Original Submittal Drawings (Section 01 33 00)

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies stranded copper cables, conductors, and wire rated 600 volts insulation used for power; lighting, analog, digital, or pulse signals and control circuits.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to document shall mean the documents in effect at the time of Advertisement for bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM B3	Soft or Annealed Copper Wire
ASTM B8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ICEA S-68-516	Ethylene-Propylene-Rubber-Insulated Wire
NEMA WC7	Cross-Linked-Thermosetting Insulated Wire and Cable for the Transmission and Distribution of Electric Energy
NFPA 70	National Electric Code (NEC)
UL 44	Rubber-Insulated Wires and Cables
UL 83	Thermoplastic-Insulated Wires and Cables

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00.
   1. Submittals specified in Section 26 05 00.
   2. Complete catalog cuts for all conductors, wire, and cable.

PART 2 PRODUCTS

2.01 GENERAL

A. Unscheduled Conductors and Cables:
   1. Where not specified on the Drawings, conductors and cables shall be sized in accordance with the National Electrical Code for the equipment served with the minimum size as specified herein. Unscheduled conductor with insulation shall be provided in accordance with the following:
      a. CABLESPEC "MEPR/CPE" multi-conductor power and control cable
      b. CABLESPEC “XHHW” for single conductors

B. Cable Specification Sheets (CABLESPEC):
   1. General requirements for conductors and cables specified in this Section are listed on CABLESPEC sheets in paragraph 3.06.

2.02 COLOR CODING

A. Control Conductors:
   1. Single-conductor control conductors shall have the following colors for the indicated voltage:

Control Conductor	120V
Power (AC)	Black
Control (AC)	Red
Neutral	White
Ground	Green
Foreign Voltage (DC)	Blue/White
Foreign Voltage (AC)	Yellow
Power (DC)	Blue
Control (DC)	Violet

B. Power Conductors:
   1. Power conductors shall have the following colors for the indicated voltage:

Power Conductor	480V	208/120V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Ground	Green	Green
Neutral	Gray	White

C. Cables may be black with colored 3/4-inch vinyl plastic tape applied at each cable termination and in pull boxes, handholes and manholes. Tape shall be wrapped with 25 percent overlay to provide 3 inches minimum coverage.

D. Signal Conductors:
   1. Signal cable conductors shall be color coded black and white for pairs or black, white, and red for triads. Each conductor and each group of conductors shall be numbered.

2.03 POWER AND CONTROL CONDUCTORS AND CABLE, 600 VOLT

A. Single Conductor:
   1. Provide stranded conductors for all cable or wires. Provide minimum conductor size of 12 AWG for power and lighting circuits and minimum conductor size of 14 AWG for control circuits.

B. Multiconductor Cable:
   1. Provide multiconductor power cable and multiconductor control cable where identified on the drawings. Provide multi-conductor cable designations as per the drawings Provide stranded conductors for all cable or wires.

2.04 SIGNAL CABLES

A. General:
   1. Factory cable between manufactured instrument system components shall be provided in compliance with the instrument manufacturer's recommendations.
   2. Signal cable shall be provided for instrument signal transmission. Single instrument cable (SIC) and multiple-circuit instrument cable (MIC) shall be provided in accordance with the following examples:
      a. CABLESPEC “SIC”:
         1) Cable designation:
            a) 1PR#16S shielded twisted pair (STP)
         2) Cable designation:
            a) 1TR#16S triad (STT)
      b. CABLESPEC “MIC":
         1) Cable designation example:
            a) 4PR#16S with individual shields for each of the four pair and an overall shield and jacket for the multiconductor instrument cable.

B. Communication, Paging, and Security System Cables:
   1. Voice communication, paging, and security system cables shall be specified in their respective specification sections.

2.05 SPLICING AND TERMINATING MATERIALS

A. Connectors shall be tool applied compression type of correct size and UL listed for the specific application. Connectors shall be tin-plated high conductivity copper. Wire nuts for a splice is prohibited.

B. Signal and control conductors shall be connected to terminal blocks and field devices and instruments shall be terminated with conductor terminals as specified in 2.10.

C. Connectors for wire sizes No. 8 AWG and larger shall be compression tool installed one-hole lugs up to size No. 3/0 AWG, and two-hole or four-hole lugs for size No. 4/0 and larger. Mechanical clamp, dimple, screw-type connectors are not acceptable. In-line splices and taps shall be used only by written consent of the Construction Manager.

D. Power conductor splices shall be compression type, made with a compression tool die approved for the purpose, as made by Thomas and Betts Corp., or equal. Splices shall be covered with electrical products designed for the application, insulated, and covered with a heat-shrinkable sleeve or boot, as specified elsewhere.

E. Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connections may use the Tyco Electronics removable boot product line.

F. Motor connection kits shall accommodate a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances. Refer to the electric motor specification Section 43 05 21.

2.06 CORD GRIPS

A. Cord grips shall be provided where indicated on the Drawings to attach flexible cord to equipment enclosures. Cord grips shall consist of a threaded aluminum body and compression nut with a neoprene bushing and stainless steel wire mesh for strain relief. Cord grip shall provide a watertight seal at enclosure interface and sized to accommodate the flexible cord.

2.07 CONDUCTOR NUMBERING

A. Conductor Numbers:
   1. Identify conductors with numbers at both ends. Conductor tag numbers are as shown in the cable schedule.
   2. Conductors in parallel or in series between equipment have the same conductor number. Neutral conductors have the same conductor number. Wherever possible, the conductor number is the same as the equipment terminal to which it connects.
   3. Where factory-wired equipment has terminal numbers different than the conductor numbers shown on the control diagrams:
      a. Show both on the interconnection diagram
      b. Include a copy of the interconnection diagram inside of the equipment cabinet.

2.08 WIRE MARKERS

A. Identify each power and control conductor at each terminal to which it is connected. Provide identification sleeves for conductors size No. 10 AWG or smaller. Use locking tab type cable markers for conductors No. 8 AWG and larger. Provide white plastic tabs with conductor identification number permanently embossed.

B. Identify conductors in accordance with paragraph 2.07 Conductor Numbering. Adhesive strips are not acceptable.

C. Machine print the letters and numbers that identify each wire on sleeves with permanent black ink with figures 1/8 inch high. Provide yellow or white tubing for sleeves sized to fit the conductor insulation. Shrink the sleeves with hot air after installation to fit the conductor.

2.09 TERMINAL BLOCKS

A. Unless otherwise specified, terminal blocks shall be panhead strap screw type. Terminals shall be provided with integral marking strips that permanently identify with the connecting wire numbers as shown on the drawings:
   1. Terminal blocks for P-circuits (power 208-600 volts)
      a. Rated not less than the conductor current rating
      b. Rated less than 600 volts AC.
   2. Terminal blocks for C-circuits and S-circuits:
      a. Rated not less than 20 amperes
      b. Rated less than 600 volts AC.
   3. Terminals shall be tin-plated.
   4. Insulating material shall be nylon.

PART 3 EXECUTION

3.01 GENERAL

A. Conductors shall be identified at each connection terminal, in pull boxes, manholes, handholes and at splice points. The identification marking system shall comply with Section 26 05 00.

B. Pulling wire and cable into conduit or trays shall be completed without damaging or putting undue stress on the insulation or jacket. Manufacture recommended and UL Listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable.

C. Raceway construction shall be complete, cleaned, and protected from the weather before cable is installed. Where wire or cable exits a raceway, a wire or cable support shall be provided.

D. Provide tin-plated bus bar. Scratch-brush the contact areas and tin plate the connection where flat bus bar connections are made with un-plated bar. Bolts shall be torqued to the bus manufacturer's recommendations.

3.02 600 VOLT CONDUCTOR AND CABLE

A. Conductors in panels and electrical equipment shall be bundled and laced at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Cable ties shall be tensioned and cut off by using a tool specifically designed for the purpose such as a Panduit GS2B. Other methods of cutting cable ties are unacceptable.

B. Conductors crossing hinges shall be bundled into groups not exceeding 10 to 15 conductors and protected using nylon spiral flexible covers to protect conductors. Provide oversized plastic panel wiring duct within panels and panelboards.

C. Slack shall be provided in junction and pull boxes, handholes and manholes. Slack shall be sufficient to allow cables or conductors to be routed along the walls. Amount of slack shall be equal to largest dimension of the enclosure. Provide dedicated electrical wireways and insulated cable holders mounted on unistrut in manholes and handholes.

D. Raceway fill limitations shall be as defined by NEC and the following:
   1. Lighting and receptacle circuits may be in the same conduit in accordance with de-rating requirements of the NEC. Lighting and receptacle circuits shall not be in conduits with power or control conductors. Signal conductors shall be in separate conduits from power and control conductors. Motor feeder circuits shall be in separate conduits including small fan circuit unless combination fan-light fixture.
   2. Power conductors derived from uninterruptible power supply systems shall not be installed in raceways with conductors of other systems. Install in separate raceways.
   3. Slices and terminations are subject to inspection by the Construction Manager prior to and after insulating.
   4. Motor terminations at 460-volt motors shall be made by bolt-connecting the lugged connectors.
   5. In-line splices and tees, where approved by the Construction Manager, shall be made with tubular compression connectors and insulated as specified for motor terminations. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin or Raychem splicing kits.
   6. Terminations at solenoid valves, 120 volt motors, and other devices furnished with pigtail leads shall be made using self-insulating tubular compression connectors within the termination box.
   7. Terminations at valve and gate motor actuators shall be made directly into the actuator where possible. Power termination shall be made in the actuator power disconnect. Control and signal cable may be routed to a termination box near the actuator on 20-ampere rated terminal strips with label identification for the control and signal conductors. Single wire control conductors and analog cable (SIC or MIC) then installed in flexible conduit to the actuator control and signal termination compartments.
   8. Install and route multi-conductor as shown on the drawings. Submit installation and routing layouts of multi -conductor cables branching out to multiple field destinations to the Engineer for pre-approval. If approved, terminate on terminals in a terminal box located adjacent to the first field device served, or in the common junction box located at the equipment as depicted on the motor feed standard detail Drawings. Make final connection to field devices with single conductors.

3.03 SIGNAL CABLE

A. Provide terminal blocks at instrument cable junctions within dedicated terminal boxes provided by the installer. Signal circuits shall be run without splices between instruments, terminal boxes, or panels.

B. Circuits shall not be made using conductors from different pairs or triads. Triads shall be used wherever 3-wire circuits are required.

C. Shields are not acceptable as a signal path, except for circuits operating at radio frequencies utilizing coaxial cables. Common ground return conductors for two or more circuits are not acceptable.

D. Unless otherwise specified, shields shall be bonded to the signal ground bus at the control panel only and isolated from ground at the field instrument or analyzer and at other locations. Shields or drain wires for spare circuits shall not be grounded at either end of the cable run. Terminals shall be provided for running signal leads and shield drain wires through junction boxes.

E. Spare circuits and the shield drain wire shall be terminated on terminal blocks at both ends of the cable run and be electrically continuous through terminal boxes.

F. Where instrument cable splicing is required, provide an instrument stand with terminal box rated for the area and environment and mounted approximately 3 feet above grade for instrument cable splices with the circuits and individual conductors provided with nameplate as specified in Section 26 05 00.

G. Cable for paging, security, voice communication, and telephone systems shall be installed and terminated in compliance with the manufacturers and the Utilities recommendations.

3.04 TESTING

A. The Contractor shall test conductors, wire, and cable in accordance with Section 26 08 00.

3.05 CABLE SPECIFICATION SHEETS (CABLESPEC)

A. General:

1. Conductor, wire, and cable types for different locations, service conditions and raceway systems are specified on individual cable specification sheets. Scheduled and unscheduled conductors, wires, and cables shall be installed in accordance with the CABLESPEC Sheets.

B. CABLESPEC Sheets:

1. The following CABLESPEC sheets are included in this section:

CABLESPEC	Volt	Product	Purpose
TCER	600	Multi-conductor power and control cable	Power and control conductors for use in cable trays and conduit raceways.
XHHW2	600	Single conductor cross-linked polyethylene power and control cable	Power and control conductors for use in conduit raceways.
VFD1	600	Shielded motor cable for VFD drives	Feeding motors fed from VFD drive for use in conduit, raceways, and Cable Tray.
VFD2	600	Shielded motor cable for VFD drives for large horsepower motors	Feeding motors fed from VFD drive for use in conduit, raceways, and Cable Tray.
INS	600	Single Pair/Triad #18 ST plus overall shield	Instrumentation, analog field devices
INSM	600	Multiple Pair/Triad #18STP plus overall shield	Instrumentation, analog field devices
NC1	300	Category 6A Ethernet, 4 pairs, U/UTP	10 Gigabit Ethernet cable unshielded
NC2	300	Category 6A Ethernet, 4 pairs, U/FTP	10 Gigabit Ethernet, shielded pairs
NC4	600	Category 6 Ethernet, 4 pairs, F/UTP	600V Gigabit Ethernet, overall foil shield, unshielded pairs
NC6		Telephone cable	Voice and Data communication cable
FOTMM	--	Fiber-optic cable – multi-mode	Data Network
FOTSM	--	Fiber-optic cable – single-mode	Data Network

CABLESPEC	TCER
Cable System Identification:	TCER
Description:	Multi conductor cross-linked polyethylene XHHW-2 power and control cable for sizes No. 14 AWG and larger. With ground. UL listed TC-ER.
Voltage:	600 volts
Conductor Material:	Bare annealed copper; stranded in accordance with ASTM B3 & B8 sizes #8 & smaller, sizes #8 & larger compact stranded per ASTM B-496
Insulation:	Cross-Linked polyethylene (XLPE) XHHW-2, 90 degree C wet or dry, in accordance with UL 1581
Assembly:	Cabled in accordance with UL 1277 and 1309. Unshielded.
Jacket:	Overall Polyvinyl Chloride(PVC) jacket
Flame Resistance:	UL 1685, IEEE 1202/FT4
Manufacturer:	Okonite X-Olene Okoseal, General Cable CVTC, or approved equal
Uses Permitted:	600V Power and Control Tray Cable and installations where TC-ER rating is permitted by the NEC.
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	MC
Cable System Identification:	MC
Description:	Multiconductor metal clad armored power and control cable, approved for tray installation and in accordance with UL 1569. Type MC-HL.
Voltage:	600 volts
Conductor Material:	Bare annealed copper; stranded in accordance with ASTM B8
Insulation:	Cross-Linked polyethylene (XLPE) XHHW-2, 90 degree C wet or dry, in accordance with UL 1581
Assembly:	Individual conductors cabled together with nonhydroscopic fillers and binding tape.
Amor	Impervious to moisture, continuous, corrugated aluminum welded over cable core. Sheath shall meet the grounding conductor requirements of NEC table 250-95
Jacket:	50 mil minimum, polyvinylchloride (PVC) in accordance with UL 1569
Flame Resistance:	IEEE 383
Manufacturer:	Okonite, C-L-X; Southwire ARMOR-X or approved equal.
Uses Permitted:	600V Power and Control Tray Cable and as depicted on the drawings
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	XHHW-2
Cable System Identification:	XHHW2
Description:	Single conductor Cross-linked polyethylene power and control cable for sizes No. 14 AWG and larger. UL listed XHHW-2.
Voltage:	600 volts
Conductor Material:	Bare annealed copper; stranded in accordance with ASTM B8
Insulation:	XHHW-2, 90 degree C wet or dry, cross-linked polyethylene in accordance with ICEA S-95-658/NEMA WC70. Insulation having integrated pre-lubrication so that that cable coefficient of friction is less than or equal to 0.17.
Flame Resistance:	UL 1685, IEEE 1202
Manufacturer:	Southwire Company SIMpull™, Encore Wire Corporation Super Slick Elite ™
Uses Permitted:	Power, control, lighting, receptacle and appliance circuits
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	VFD1
Cable System Identification:	VFD1
Description:	Shielded for VFD drives. Multi conductor cross-linked polyethylene XHHW-2 or RHW-2 power cable with ground the same size as phase conductors. UL listed TC-ER. Conductor sizes 12 AWG though 2 AWG.
Voltage:	600 volts
Conductor Material:	Tinned copper. Class D, Class K, or Class H stranded.
Insulation:	90 degree C dry or wet, crosslinked polyethylene XLPE in accordance with NEMA. UL listed XHHW-2 or RHW-2.
Shield	100% shielding with aluminum foil tape and tinned copper braid (85% coverage). Drain conductor same size as phase conductor.
Jacket:	Black jacket. PVC or Thermoplastic Elastomer. UL TC-ER listed. Minimum cable bend radius recommended by the manufacturer than or equal to 15x the cable diameter.
Flame Resistance:	UL 1685, IEEE 1202
Manufacturer:	3#12, 1#12 ground, 1#12 drain: Southwire 585344, Belden 29502, or equal 3#10, 1#10 ground, 1#10 drain: Southwire 585416, Belden 29503, or equal 3#8, 1#8 ground, 4#14 drain: Southwire 643451, Belden 29504, or equal 3#6, 1#6 ground, 4#12 drain: Southwire 643459, Belden 29505, or equal 3#4, 1#4 ground, 4#10 drain: Southwire 643467, Belden 29506, or equal 3#2, 1#2 ground, 4#8 drain: Southwire 643474, Belden 29507, or equal
Uses Permitted:	Cable tray and conduit exposed in non-classified or Class I, Division 2 per NEC 336, 392 and 501 environment.
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00.
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	VFD2
Cable System Identification:	VFD2
Description:	Shielded for VFD drives. Multi conductor cross-linked polyethylene XHHW-2 or RHW-2 power cable with three symmetrical stranded grounds. The sum of the three ground's size (circular mills) equal to or greater than the size of a phase conductor. UL listed TC-ER. Conductor sizes 1 AWG though 4/0 AWG.
Voltage:	600 volts
Conductor Material:	Tinned copper. Class B, Class D, or Class K stranded
Insulation:	90 degree C dry or wet, crosslinked polyethylene XLPE in accordance with NEMA. UL listed XHHW-2 or RHW-2.
Shield:	Two spirally applied 2 mil copper tapes with 100 percent coverage.
Jacket:	Black PVC jacket. UL TC-ER listed. Minimum cable bend radius recommended by the manufacturer than or equal to 15x the cable diameter.
Flame Resistance:	UL 1685, IEEE 1202
Manufacturer:	3#1/0, 3#4G ground: General Cable 438200, Belden 29529, or approved equal 3#2/0, 3#4G ground: General Cable 438210, Belden 29530, or approved equal
Uses Permitted:	Cable tray or conduit., exposed in non-classified or Class I, Division 2 per NEC 336, 392 and 501 environment.
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00.
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	CORD
Cable System Identification:	CORD
Description:	Portable Cord, 3-conductor with ground, extra hard usage, oil, weather and water resistant. 10 AWG and smaller, UL listed, type SOOW; larger than 10 AWG, UL listed type G/GC
Voltage:	600 volts
Conductor Material:	Type G/GC - Flexible rope lay stranded per ASTM B189 and B33. Type SOOW – Soft bare annealed copper per ASTM B-3, flexible bunch strand per ASTM B-174.
Insulation:	Insulation shall be ethylene propylene (EPR) as per ICEA S-68-516 and rated for continuous operation at 90 degrees C Dry and 75 degrees C Wet.
Jacket:	Black chlorinated polyethylene (CPE) rubber ICEA S-98-658.
Manufacturer:	Type SOOW - Paige Electric SOOW, Southwire Royal, or approved equal. Type G/GC - Paige Electric G/GC, Southwire Royal, or approved equal.
Uses Permitted:	In accordance with NEC. Design and installation for all CORD use for permanently installed equipment must be approved by Owner. For temporary construction use as approved by Owner, Construction Manager, or AHJ. Cables shall be sized by Contractor for load served.
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00. Provide cable seals where required by NEC 501.
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	INS
Cable System Identification:	INS
Description:	Single twisted, shielded pair or triad, instrumentation cable. Rated 90 degree C wet or dry. UL listed TC.
Voltage:	600 volts
Conductor Material:	Bare annealed copper; stranded in accordance with ASTM B-8
Insulation:	PVC/Nylon
Jacket:	Polyvinylchloride (PVC) per UL Standard 1277
Lay:	Twisted on a 2-inch lay
Shield:	100 percent, 1.35 mil aluminum-Polyester tape with 20 AWG 7-strand tinned copper drain wire
Flame Resistance:	UL 1685, ICEA T-29-520 and IEEE 1202.
Manufacturer:	Single Pair #18: BELDEN 1120A, Okononite Okoseal-N P-OS 264-60-3301, or equal. Single Triad #18: BELDEN 1121A, Okononite Okoseal-N P-OS 264-65-3301, or equal. Single Pair #16: BELDEN 1118A, Okononite Okoseal-N P-OS 264-60-4401, or equal. Single Triad #16 BELDEN 1119A, Okononite Okoseal-N P-OS 264-65-4401, or equal. Single Pair #14: Okononite Okoseal-N P-OS 264-60-5501, or equal. Single Triad #14: Okononite Okoseal-N P-OS 264-65-5501, or equal.
Uses Permitted:	Instrumentation cable tray, raceway
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00.
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	INSM
Cable System Identification:	INSM
Description:	Multiple twisted, shielded pairs or triads, instrumentation cable. Rated 90 degree C wet or dry. UL listed TC.
Voltage:	600 volts
Conductor Material:	Bare annealed copper; stranded in accordance with ASTM B-8
Insulation:	PVC/Nylon
Jacket:	Polyvinylchloride (PVC) per UL Standard 1277
Lay:	Twisted on a 2-inch lay
Shield:	100 percent, 1.35 mil aluminum-Polyester tape with 20 AWG 7-strand tinned copper drain wire
Flame Resistance:	UL 1685and IEEE 1202
Manufacturer:	2 pair #18: BELDEN 1048A, or equal. 4 pair #18: BELDEN 1049A, Okonite Okoseal-N SP-0S 261-60-3304, or equal. 8 pair #18: BELDEN 1050A, Okonite Okoseal-N SP-0S 261-60-3308, or equal. 12 pair #18: BELDEN 1051A, Okonite Okoseal-N SP-0S 261-60-3312, or equal. 16 pair #18: BELDEN 1052A, Okonite Okoseal-N SP-0S 261-60-3316, or equal. 20 pair #18: Okonite Okoseal-N SP-0S 261-60-3320, or equal. 24 pair #18: BELDEN 1053A, Okonite Okoseal-N SP-0S 261-60-3324, or equal. 36 pair #18: BELDEN 1054A, Okonite Okoseal-N SP-0S 261-60-3336, or equal. 50 pair #18: Okonite Okoseal-N SP-0S 261-60-3350, or equal. 4 triad #18: BELDEN 1093A, Okonite Okoseal-N SP-0S 261-65-3304, or equal. 8 triad #18: BELDEN 1094A, Okonite Okoseal-N SP-0S 261-65-3308, or equal. 12 triad #18: BELDEN 1095A, Okonite Okoseal-N SP-0S 261-65-3312, or equal. 16 triad #18: Okonite Okoseal-N SP-0S 261-65-3316, or equal. 24 triad #18: BELDEN 1096A, Okonite Okoseal-N SP-0S 261-65-3324, or equal. 36 triad #18: Okonite Okoseal-N SP-0S 261-65-3336, or equal. 2 pair #16: BELDEN 1069A, Okonite Okoseal-N SP-0S 261-60-4402, or equal. 4 pair #16: BELDEN 1070A, Okonite Okoseal-N SP-0S 261-60-4404, or equal. 8 pair #16: BELDEN 1071A, Okonite Okoseal-N SP-0S 261-60-4408, or equal. 12 pair #16: BELDEN 1072A, Okonite Okoseal-N SP-0S 261-60-4412, or equal. 16 pair #16: BELDEN 1073A, Okonite Okoseal-N SP-0S 261-60-4416, or equal. 20 pair #16: Okonite Okoseal-N SP-0S 261-60-4420, or equal. 24 pair #16: BELDEN 1074A, Okonite Okoseal-N SP-0S 261-60-4424, or equal. 36 pair #16: Okonite Okoseal-N SP-0S 261-60-4436, or equal. 50 pair #16: Okonite Okoseal-N SP-0S 261-60-4450, or equal. 4 triad #16: BELDEN 1097A, Okonite Okoseal-N SP-0S 261-65-44004, or equal. 8 triad #16: BELDEN 1098A, Okonite Okoseal-N SP-0S 261-65-4408, or equal. 12 triad #16: BELDEN 1099A, Okonite Okoseal-N SP-0S 261-65-4412, or equal. 16 triad #16: Okonite Okoseal-N SP-0S 261-65-4416, or equal. 24 triad #16: Okonite Okoseal-N SP-0S 261-65-4424, or equal. 36 triad #16: Okonite Okoseal-N SP-0S 261-65-4436, or equal.
Uses Permitted:	Instrumentation cable tray, raceway
Execution – Installation:	Install in accordance with Section 26 05 19 and 26 05 00.
Execution – Testing:	Test in accordance with Section 26 05 19, 26 05 00, and 26 08 00

CABLESPEC	NC1
Cable System Identification:	NC1
Description:	Category 6A Ethernet, IEEE 802.3 10G and PoE Ethernet, ISO/IEC Class EA. Unshielded 4 pair. UL CMP.
Voltage:	300V rms
Conductor Material:	Solid bare copper 23 AWG
Insulation:	Fluoropolymer (FEP)
Jacket:	CMP, 75 degree C minimum
Jacket Color:	Blue or white, as specified on Instrumentation Drawings
Shield:	Unshielded
Flame Resistance:	NFPA 262
Electrical Characteristics:	Maximum Insertion loss 45.3 dB at 100 meters and 500 MHz IEEE 802.3af/at/bt (PoE/PoE+) rated for applications up to 100 watts
Manufacturer:	Leviton eXtreme Cat 6A U/UTP Plenum Rated, or approved equal.
Uses Permitted:	Conduit, cable tray.
Execution – Application:	Data Network Communications – Ethernet.
Execution – Installation:	Install in accordance with this Section and associated equipment manufacturer's instruction.
Execution – Testing:	Test in accordance with this Section.

CABLESPEC	NC2
Cable System Identification:	NC2
Description:	Category 6A Ethernet, IEEE 802.3 10G and PoE Ethernet, ISO/IEC Class EA. 4 shielded pair. UL CMP.
Voltage:	300V rms
Conductor Material:	Solid bare copper 23 AWG
Insulation:	Fluoropolymer (FEP)
Jacket:	CMP, 75 degree C minimum
Jacket Color:	Blue or white, as specified on Instrumentation Drawings.
Shield:	Each pair shielded with aluminum foil. Solid tinned copper 24 AWG drain wire
Flame Resistance:	NFPA 262 CMP
Electrical Characteristics:	Maximum Insertion loss 45.3 dB at 100 meters and 500 MHz IEEE 802.3af/at/bt (PoE/PoE+) rated for applications up to 100 watts
Manufacturer:	General Cable GenSPEED 10,000 Cat 6A U/FTP Plenum Rated, or approved equal
Uses Permitted:	Conduit, cable tray.
Execution – Application:	Data Network Communications – Shielded Ethernet.
Execution – Installation:	Install in accordance with this Section and associated equipment manufacturer's instruction.
Execution – Testing:	Test in accordance with this Section.

CABLESPEC	NC3
Cable System Identification:	NC3
Description:	Category 6A Ethernet, IEEE 802.3 10G and PoE Ethernet, ISO/IEC Class EA. 4 pair with overall shield. Outside Plant (OSP) Gel-Filled.
Voltage:	300V rms
Conductor Material:	Solid bare copper 23 AWG
Insulation:	Polyolefin (PO)
Jacket:	Polyethylene
Shield:	Overall aluminum foil shield
Flame Resistance:	None
Electrical Characteristics:	Maximum Insertion loss 45.3 dB at 100 meters and 500 MHz
Manufacturer:	Belden OSP6AF or approved equal.
Uses Permitted:	Conduit.
Execution – Application:	Outdoor Data Network Communications – Ethernet.
Execution – Installation:	Install in accordance with this Section and associated equipment manufacturer's instruction.
Execution – Testing:	Test in accordance with this Section.

CABLESPEC	NC4
Cable System Identification:	NC4
Description:	Category 6 Ethernet, 1 Gigabit Ethernet, ISO/IEC Class E. 4 pair with overall shield. UL CMR.
Voltage:	600V rms
Conductor Material:	Solid bare copper 23 AWG
Insulation:	Polypropylene (PP)
Jacket:	Inner PVC Jacket (PVC), Outer PVC Jacket
Jacket Color:	Blue
Shield:	Shielded, overall aluminum-polyester tape 100 percent coverage with 24 AWG tinned copper drain wire
Flame Resistance:	UL 1666 riser
Electrical Characteristics:	Maximum Insertion loss 32.8 dB at 100 meters and 250 MHz
Manufacturer:	Belden 7953A or approved equal
Uses Permitted:	Conduit, cable tray.
Execution – Application:	Data Network Communications – Shielded Ethernet.
Execution – Installation:	Install in accordance with this Section and associated equipment manufacturer's instruction.
Execution – Testing:	Test in accordance with this Section.

CABLESPEC	NC5
Cable System Identification:	NC5
Description:	Paired – Low Capacitance, Computer Cable for EIA RS-232/485. UL TC.
Voltage:	600 volts, 75 degree C
Conductor Material:	2 pair, stranded, Tinned Copper,.18 AWG
Insulation:	Flame Retardant Polyolefin
Jacket:	PVC – Polyvinyl Chloride
Lay:	Twisted on a .75-inch lay
Shield:	Beldfoil®, Tape/Braid Layer 1: Tape, Aluminum/polyester shield with 100% coverage Layer 2: Braid, TC – Tinned Copper
Flame Resistance:	UL 1685
Manufacturer:	Belden 3074F or approved equal.
Uses Permitted:	Conduit
Execution – Installation:	Install in accordance with this Section
Execution – Testing:	Test in accordance with this Section and 26 08 00

CABLESPEC	NC6
Cable System Identification:	NC6
Description:	Telephone–Voice and Data communication cable, aluminum shield, solid annealed copper.
Code:	UL listed and NEC Type CMP
Conductor(s):	006 pair No. 24 AWG solid annealed copper 012 pair No. 24 AWG solid annealed copper 025 pair No. 24 AWG solid annealed copper 050 pair No. 24 AWG solid annealed copper 100 pair No. 24 AWG solid annealed copper
Insulation:	Thermoplastic
Jacket:	FR, low smoke Polyvinyl chloride
Shield:	Aluminum
Characteristic Impedance:	100±15Ω
Manufacturer:	General Cable or approved equal (006 pair GC##7527112) (012 pair GC##7527120) (025 pair GC##7527138) (050 pair GC##7527146) (100 pair GC##7527161)
Uses Permitted:	Conduit
Execution – Installation:	Install in accordance with this Section and with equipment vendor specifications.
Execution – Testing:	Test after installation in accordance with this Section.

CABLESPEC	FOT-MM
Cable System Identification:	FOT-MM
Description:	Multi-mode (OM3) Fiber-Optic Data Cable; indoor/outdoor, distribution loose-tube, UV stabilized, gel-free, fiber conductor: Outdoor/Indoor; Plenum Rated; Cable Tray Rated Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598.
Type:	OFNP with industrial cable tray rating and NFPA 262 flame test rated Fiber Type: Multi-Mode (OM3) Standards Compliance: TIA-492AAAC (OM3) Cladding Diameter: 125 ± 1.0 µm Core Diameter: 50.0 µm Attenuation: ≤ 3.00 db/km @ 850 nm ≤ 1.00 db/km @ 1300 nm Operating Temperature Range: -40 to +70 Deg C Maximum Tensile Loading: 6-strand: 300/90 lbf (short-term/long-term) 12-strand: 300/90 lbf (short-term/long-term) Minimum Cable Bending Radius: 6-strand: 3.2”/2.1” (loaded/unloaded) 12-strand: 4.1”/2.7” (loaded/unloaded) Compression Rating: 126 lb/in or greater Cable Outer Diameter: 6-strand: 0.21” 12-strand: 0.27”
Insulation:	
Jacket:	UV stabilized, fungus and moisture resistant. Designed for indoor/outdoor installations, including cable trays. Color: Black Mark the exterior sheathing with the manufacturer's name, month and year of manufacture, and sequential meter or foot markings for easily determining the length of the cable at all points along the cable run.
Manufacturer:	Commscope LazrSPEED Indoor/Outdoor Plenum Distribution Cable, or approved equal.
Execution – Application:	Data Communications
Execution – Installation:	(1) Fiber-optic cable shall be suitable for installation in conduit runs, plenum and riser spaces, and cable trays within buildings. (2) Fiber-optic cable shall be suitable for installation between buildings in outdoor/concrete encased conduit runs which share vaults with medium voltage cable. (3) Fiber shall be terminated with LC style connectors unless otherwise shown on drawings or required by the manufacturer. (5) Fiber-optic cables shall have number of fibers as shown in the documents.
Execution – Testing:	Test in accordance with this Section.

CABLESPEC	FOT-SM
Cable System Identification:	FOT-SM
Description:	Single-Mode (OS2) Fiber-Optic Data Cable; indoor/outdoor, distribution (loose-tube), UV stabilized, gel-free, fiber conductor: Outdoor/Indoor; Plenum Rated; Cable Tray Rated Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598.
Type:	OFNP with industrial cable tray rating and NFPA 262 flame test rated Fiber Type: Single-Mode (OS2) Standards Compliance: ITU-T G.652.D, ITU-T G.657.A1 Cladding Diameter: 125 ± 0.7 µm Core Diameter: 9 µm Attenuation: ≤ 0.5 db/km @ 1310 nm ≤ 0.5 db/km @ 1550 nm Operating Temperature Range: -40 to +70 Deg C Maximum Tensile Loading: 24-strand: 300/90 lbf (short-term/long-term) 48-strand: 800/240 lbf (short-term/long-term) 96-strand: 1000/300 lbf (short-term/long-term) 144-strand: 1000/300 lbf (short-term/long-term) Minimum Cable Bending Radius: 24-strand: 4.7”/3.1” (loaded/unloaded) 48-strand: 11.1”/7.4” (loaded/unloaded) 96-strand: 16.7”/11.1” (loaded/unloaded) 144-strand: 17.9”/11.9” (loaded/unloaded) Compression Rating: 126 lb/in or greater Cable Outer Diameter: 24-strand: 0.31” 48-strand: 0.74” 96-strand: 1.11” 144-strand: 1.19”
Jacket:	UV stabilized, fungus and moisture resistant. Designed for indoor/outdoor installations, including cable trays. Color: Black Mark the exterior sheathing with the manufacturer's name, month and year of manufacture, and sequential meter or foot markings for easily determining the length of the cable at all points along the cable run. Provide a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code® (NESC®), fiber count, and fiber type.
Manufacturer:	Commscope TeraSPEED Indoor/Outdoor Plenum Distribution Cable, or approved equal
Execution – Application:	Data Communications
Execution – Installation:	(1) Fiber-optic cable shall be suitable for installation in conduit runs, plenum and riser spaces, and cable trays within buildings. (2) Fiber-optic cable shall be suitable for installation between buildings in outdoor/concrete encased conduit runs which share vaults with medium voltage cable. (3) Fiber shall be terminated with LC style connectors unless otherwise shown on drawings or required by the manufacturer. (4) Fiber-optic cables shall have number of fibers as shown in the documents.
Execution – Testing:	Test in accordance with this Section

END OF SECTION

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SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the system for grounding electrical distribution and utilization equipment, including but not limited to cabinets, motor frames, manholes, instrumentation, metal surfaces of process/mechanical equipment that contain energized electrical components, metal structures and buildings, outdoor metal enclosures, fences and gates.

B. The Equipment Grounding Conductor shall ground or bond equipment, structures, or equipment frames to the Grounding Electrode System as defined in the National Electrical Code Article 250 and addressed herein.

C. The minimum size of the Equipment Grounding Conductors installed with the circuit conductors shall be per the National Electrical Code Table 250.122. The circuit grounding conductor size routed with a feeder or branch circuit conductors is as shown on the drawings.

1.02 REFERENCES:

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE Std 81.2-1991	Guide to Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems
NETA - ATS	InterNational Electrical Testing Association Inc. - Acceptance Testing Specifications
NFPA 70	National Electric Code (NEC) Article 250

1.03 SUBMITTALS:

A. The following information shall be submitted for review in accordance with Section 01 33 00:

B. Product Literature:
   1. Marked product literature for ground rods, test wells, and equipment ground plate.

PART 2 PRODUCTS

2.01 GROUND CONDUCTORS

A. The System Ground Conductor shall be soft-drawn, bare annealed copper, concentric stranded, as specified. The minimum sizes shall be as follows, where American Wire Gage (AWG) conductor sizes are not shown or specified:

1.	15 kV-5 kV transformers	2/0 or 4/0 AWG
2.	5 kV-480V transformers	2/0 or 4/0 AWG
3.	480V switchgear	2/0 or 4/0 AWG
4.	480V switchboards	2/0 or 4/0 AWG
5.	480V MCC and	2/0 or 4/0 AWG
6.	Cable tray	2/0 or 4/0 AWG
7.	Large motors 250 hp & >	2/0 or 4/0 AWG
8.	Lighting & Power panels	2 AWG
9.	Exposed metal cabinets	2 AWG
10.	Electrical equipment	2 AWG
11.	Buildings and enclosure	2 AWG
12.	Fences and gates	2 AWG
13.	Motors 25 hp to 250 hp	2 AWG
14.	Motors 1 hp to 25 hp	6 AWG

2.02 GROUND RODS

A. Ground rods shall be copper covered steel, 3/4-inch diameter and 10-feet long. Rods shall have threaded type removable caps so that extension rods of same diameter and length may be added where necessary.

2.03 COMPRESSION CONNECTORS

A. Compression connections shall be irreversible, cast copper as manufactured by Thomas and Betts, or equal.

2.04 BOLTED CONNECTORS

A. Bolted connectors shall be Burndy, O. Z. Gedney, or equal.

2.05 WELDED CONNECTORS

A. Exothermic welding products shall be Erico's Cadweld Plus system with a remotely operated battery powered electronic ignition device and moisture resistant weld metal cup for the required mold, or equal.

2.06 TEST WELLS

A. Provide concrete test well with cover and connect the ground grid extension using a removable connector.

2.07 EQUIPMENT GROUND BARS

A. Copper equipment ground bars shall be Erico Eritech EGB Series or equal, sized as required for the installation.

2.08 GROUND ELECTRODE GROUNDING BARS

A. Ground electrode grounding bars shall be 1/4-inch thick copper electro-tin plating, Erico Eritech EGBA Series CC Pattern, Burndy Type BBB or equal. Minimum length shall be 12 inches.

B. Insulators (Stand Off) material shall be halogen-free, fiberglass-reinforced thermal set unsaturated polyester molded compound with indoor rating of 600 volts.

C. Brackets shall be 1/8-inch thick, Type 304 stainless steel.

D. Fasteners shall be 3/8-inch Type 304 stainless steel.

2.09 EQUIPMENT GROUND PLATE

A. Equipment ground plate shall be two-hole copper flush mounted grounding plate, Erico Cadweld, Burndy YGF Series, or equal.

2.10 PRODUCT DATA

A. Ground resistance readings specified in Part 3 below shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding system shall be provided in compliance with the NFPA 70 National Electrical Code (NEC). Grounding conductor shall not be used as a system neutral.

B. Embedded and buried ground connections shall be made by compression connectors utilizing diamond or hexagon dies and a hand compression tool for wire sizes 2 AWG and smaller and a hydraulic pump and compression head for wire sizes 2/0 AWG and larger. Alternate method allowed: exothermic welding using a remote igniter device.

C. Tools and dies shall be approved for this purpose; dimple compressions are not acceptable. Compression connections shall be prepared in accordance with the manufacturer's instructions. Compression-type lugs shall be used in accordance with manufacturer's recommendations. Exposed ground connections to equipment shall be made by bolted clamps unless otherwise specified. No solder material shall be used in any part of the ground circuits.

D. Embedded ground conductors and fittings shall be securely attached to concrete reinforcing steel with tie wires and prevented from displacement during concrete placement.

E. Notify the Construction Manager two hours prior to backfilling, as each part of the grounding system installed below finished grade is complete and ready for inspection. Non-compliance shall affect the payment schedule for this work.

F. Grounding conductors extended beyond concrete surfaces for equipment connection shall be extended a sufficient length to reach the final connection point without splicing. Provide grounding fittings, pads, or plates as shown in the electrical details. Minimum grounding conductor extension shall be 3-feet.

G. Grounding conductors which project from a concrete surface shall be located as close as possible to a corner of the equipment pad, protected by rigid conduit bonded to the grounding conductors, or terminated in a flush grounding plate.

H. Exposed grounding conductors shall be supported by noncorrosive metallic hardware at 4-foot intervals or less. Grounding conductors for shown and future equipment shall be terminated using an equipment grounding plate.

I. Ground conductors entering electrical enclosures shall be bonded to a single ground bus or terminal strip in the enclosure and to metallic raceways within or terminating at the enclosure. Direct ground connections to enclosure chassis or back plate are not acceptable. Prior to making ground connections or bonds, the metal surface at the point of connection shall be cleaned.

J. Lightning arresters shall be directly connected to the ground grid system using lightning industry braided copper conductors, sized as specified.

K. Metallic sheaths or shields of shielded power cable shall be terminated by a copper ground bus provided with cable connection for connection to the grounding system.

3.02 RACEWAY GROUND

A. All service, feeder and branch circuit raceways shall contain a green insulated ground conductor sized per applicable NFPA 70 National Electrical Code (NEC) tables:
   1. T250.66 - Grounding Electrode Conductor for Alternating - Current Systems or
   2. T250.122 - Minimum Size Equipment Grounding Conductors for Grounding Raceways and Equipment.

B. Metallic conduits terminating at concentric knock-outs or reducing washers shall be bonded using insulated grounding bushings. Grounding bushings shall be connected to the grounding system using conductors sized in compliance with NEC.

C. Cable trays shall have 2/0 or 4/0 bare copper ground conductor run on the outside of each tray or tray group of tiered cable tray. Conductor shall be connected to each section or fitting using an approved ground-clamp and supported at 5 foot intervals.

3.03 EQUIPMENT AND ENCLOSURE BONDING

A. Electrical distribution and utilization equipment enclosure ground bus, motor frames, manholes, metal structures and buildings, outdoor metal enclosures, fences and gates shall be bonded to the grounding system with conductor sizes as specified.

B. Connect the conductor to the metal enclosure using a UL listed connector, where the enclosure does not contain an internal ground bus

C. Non-electrical equipment with metallic enclosures, that are located outdoors and without a cover or a shade, shall be connected to the grounding system.

3.04 ISOLATED GROUNDING

A. An isolated ground system shall be installed where required by an equipment manufacturer. The isolated ground conductor shall have green insulation with a yellow stripe and shall be run in the same raceway as the power and neutral conductors. The isolated ground bus shall be kept isolated from neutral and grounding buses.

B. Where specifically directed by the Engineer and required by an equipment manufacturer, the Contractor shall provide an additional isolated ground conductor from the service or separately derived system to an isolated ground bus bar at each associated distribution point.

3.05 SERVICE AND SEPARATELY DERIVED SYSTEM BONDING

A. A neutral bonding jumper shall be installed in only one location for each service or separately derived system. The bonding jumper shall be located at the service source or the first immediate distribution point downstream from the source. The neutral and ground buses shall be kept isolated from each other accept where the bonding jumper is installed.

3.06 GROUNDING SYSTEM TESTS

A. The Contractor shall test the facility grounding system and the building grounding system to determine the ground resistance. The grounding test shall be IEEE Standard 81 using the NETA Fall-of-Potential procedure. A plot of ground resistance readings for each isolated ground rod, ground mat, or ground bus shall be submitted on 8-1/2 x 11 inch size graph paper. Point-to-point resistance measurements are not acceptable.

B. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test or as recommended by IEEE Standard 81. The measurements shall be made at 10-foot intervals beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.

C. A grounding system that shows greater than 2 ohm resistance for the flat portion of the plotted data shall be considered inadequately grounded.

D. The Contractor shall add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurements meet the 2 ohm requirement. Additional ground rods will be paid for as extra work where the required numbers exceed that specified when authorized and approved by the Construction Manager.

E. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SCOPE

A. This section covers the furnishing and installation of electrical conduits, wireways, pull boxes, manholes, handholes, cable trays, fittings and supports. Raceways shall be provided for lighting, receptacles, power, control, instrumentation, signaling and grounding systems.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI C80.1	Rigid Steel Conduit-Zinc Coated
ANSI C80.3	Electrical Metallic Tubing-Zinc Coated
ASTM F512	Smooth-Wall Polyvinylchloride Conduit and Fittings for Underground Installation
FEDSPEC WW-C-581E	Conduit, Metal, Rigid and Intermediate; and Coupling, Elbow, and Nipple, Electrical Conduit; Zinc Coated
FEDSPEC W-C-1094A	Conduit and Conduit Fittings, Plastic, Rigid
JIC EMP-1	Electrical Standards for Mass Production Equipment
NEMA ICS 6	Industrial Control and Systems Enclosures
NEMA TC2	Electrical Plastic Tubing (EPT) and Conduit (EPC 40 and EPC 80)
NEMA TC6	PVC and ABS Plastic Utilities Duct for Underground Installation
NEMA VE1	Cable Tray Systems
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NFPA 70	National Electrical Code (NEC)
NFPA 79	Electrical Standards for Industrial Machinery
IBC	International Building Code
UL 1	Flexible Metal Electrical Conduit
UL 6	Rigid Metal Electrical Conduit
UL 360	Liquid Tight Flexible Electrical Conduit

Reference	Title
UL 514	Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
UL 651	Rigid Nonmetal Electrical Conduit
UL 797	Electrical Metallic Tubing
UL 870	Wireways, Auxiliary Gutters, and Associated Fittings
UL 884	Underfloor Raceways and Fittings
UL 886	Outlet Boxes and Fittings for Hazardous (Classified) Locations

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:

B. Products:
   1. Manufacturer's descriptive literature for materials.
   2. Certification that Contractor has been trained to work on PVC-coated conduit systems.

C. Underground Conduit Raceway System:
   1. The Contractor shall provide detailed layout drawings or sketches for the underground conduit raceway systems. Make take-offs of the circuits and underground raceways required between electrical power and control equipment, process equipment, instrumentation, area lighting, receptacles, heat tracing, and eye-wash stations to assure all circuit are included prior to system construction.
   2. Drawings shall show plan view routing, pullboxes and manholes, consideration of other underground systems and structures, approximate system cover depths and widths, and section views showing sizes of conduits and circuits. Submit the underground conduit raceway systems drawings or sketches.

PART 2 PRODUCTS

2.01 RACEWAYS AND FITTINGS

A. General requirements for raceway materials specified in this section are listed in the RACESPECS sheets at the end of this section. The type of raceways and raceway fittings to be used for any given area and application shall conform to the requirements in this section.

2.02 BOXES, GUTTERS, TERMINAL CABINETS, MANHOLES, AND HANDHOLES

A. Materials and classifications of equipment and material is specified in Section 26 05 00

B. Pull Boxes And Wiring Gutters:
   1. Indoor boxes and enclosures larger than FD boxes shall be constructed of sheet steel and galvanized after fabrication. Outdoor boxes and enclosures shall be provided with neoprene gaskets on the hinged doors and removable covers. Box and gutter sizes, metal thickness, and grounding shall comply with the National Electrical Code. Bolt-on junction box covers 3 feet square or larger, or heavier than 25 pounds, shall have a rigid handle. Covers larger than 3 x 4 feet shall be split.

C. Terminal Cabinets:
   1. Terminal cabinets shall be provided with adjustable terminal strip mounting, back-panels for equipment mounting, print pockets in the doors, continuous door hinges, and three-point lockable latches.
   2. Classifications, ratings and enclosure material is specified in 01 61 45 and 26 05 00.

D. Manholes:
   1. Unless otherwise specified, manholes shall be precast concrete, 3000 psi strength at 28 days, with reinforcing with the manhole cover designed for H 20 bridge loading. Necking and shaft shall have 36 inch minimum clear opening.
   2. Manhole dimensions shall be as shown on the drawings and where not shown shall be sized in accordance with the NEC. Manhole cover and frame shall be Class 30B gray cast iron per ASTM A48 with machine finished flat bearing surfaces. Manhole covers shall be engraved " ELECTRICAL – LOW VOLTAGE". 2. “ELECTRICAL – MEDIUM VOLTAGE". 3. “SIGNAL/COMMUNICATIONS". " as appropriate.
   3. Manholes shall be watertight. Exterior walls of manholes shall be provided with 6 mils of waterproof membrane, Sonneborn HLM 5000 Series, or equal. Manhole walls shall be provided with boxouts with waterstops on all sides of each boxout. Waterstops shall be as specified in the Cast-in-Place Concrete section.
   4. Raceway duct entries shall be no less than 14 inches above floor and below ceiling. Raceway boxouts shall be sized to accommodate the penetrating underground duct banks. Raceways bell-ends shall be flush with the interior finished manhole wall. From each duct bank entry into the manhole, the continuous duct bank bare copper grounding conductor shall be supported and routed around the interior manhole walls and bonded together.
   5. Floor shall slope to a sump pit with dimensions shown in the manhole detail or with a minimum of 18 inch length x 18 inch width x 12 inches depth.

E. Handholes:
   1. Handholes shall be precast concrete with checker plate, galvanized, traffic covers designed for H 20 loading. Handholes shall be provided with precast solid concrete slab bottoms with sumps. Handholes shall be constructed of 3000 psi reinforced concrete. Handhole cover shall be engraved "ELECTRICAL" or "SIGNAL" as applicable.
   2. Dimensions shall be as specified on the drawings. Handhole walls shall be provided with boxouts, as specified for manholes.

F. Manhole And Handhole Cable Supports:
   1. Provide heavy-duty, non-metal cable racks for support of conductors. Racks shall be UL listed glass-reinforced nylon consisting of slotted wall brackets for support arms designed for a minimum of a 400-pound load. Each support bracket shall from the top to the bottom and the arms shall be adjustable and installed on 24-inch centers. Use ½-inch stainless steel bolts, hardware, inserts, and fasteners. Cables supports, clamps or racks shall be provided to support the cable at minimum 2-foot intervals. Concrete inserts shall be embedded on 24-inch centers in walls and ceiling.
   2. Cable Support Products:
      a. Underground Devices Incorporated Type RA arms with CR36 support brackets.
      b. Unistrut Power-Rack F20N-STA33 Stanchions with F20N-ARM14 Arms.

c. Or equal

G. Ground Bus:

1. Provide a ground bus in concrete manholes, handholes, and electrical pullboxes with dimension of 3-foot width x 3-foot length x 3-foot depth and larger. Provide a NEMA threaded 4-hole grounding plate for connecting two to four-1-hole ground connectors that enter the enclosure from two to four duct banks. From each duct bank entry into the manhole, the continuous duct bank bare copper grounding conductor shall be supported and routed around the interior manhole walls and bonded together or to a ground bus

a. Products:

1) Burndy, T&B, or equal.

2.03 RACEWAY SUPPORTS

A. Conduit Supports:

1. Framing channel with end caps and straps shall be provided to support groups of conduit. Individual conduit supports shall be one-hole pipe straps used with clamp backs and nesting backs where required
2. Conduit supports shall be one-hole clamps or oversized clamps with clamp backs and nesting backs where required .
3. Fiberglass spray sealant shall be applied to all field cuts made to fiberglass framing channel.

B. Ceiling Hangers:

1. Ceiling hangers shall be adjustable. Provide J-Type conduit support for single conduit. Straps or hangers of plumber's perforated tape are not acceptable. Unless otherwise shown, hanger rods shall meet ASTM A193 and be sized as 3/8-inch up to 2-inch conduit and shall be 1/2 inch all-thread rod over 2-inch conduit. .
2. Ceiling hangers for fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic threaded rod hangers with FRP fasteners.

C. Suspended Raceway Supports and Racks:

1. Suspended raceway supports shall consist of concrete inserts, rod hangers, and jamb nuts supporting framing channel or lay-in pipe hangers as required. Framing channel shall be a minimum of 12-gauge.
2. Hanger rods supporting fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic with FRP or nylon jamb nuts.
3. Hanger rods shall be 1/2-inch diameter all-thread rod and shall meet ASTM A193. Suspended raceway supports and racks shall be braced for seismic forces as specified in Section 26 05 00.

D. Materials:

1. Mounting and supporting material and ratings are specified in Section 26 05 00

2.04 CONCRETE ENCASED DUCT BANKS

A. Concrete used for duct banks shall be Class E and a minimum 28-day compressive strength of 2,000 psi as specified in the Cast-in-Place Concrete Section 03 30 00.

2.05 UNDERGROUND MARKING TAPE

A. Underground detectable marking tape shall be for early warning protection of digging around direct buried cables, conduits, and concrete duct banks. Tape shall be OSHA approved.

B. Marking Tape Example:
   1. tape example: Low density polyethylene plastic, nominally 6 inches wide and 4 mil thickness with metallic lined tape with red polyethylene film on top and clear polyethylene film on the bottom. Tape shall be imprinted with a warning continuously along the length similar to: "CAUTION - STOP DIGGING - BURIED ELECTRIC LINE BELOW."

C. Tape Products:
   1. Brady "Identoline"; Services and Materials "Buried Underground Tape"; Somerset (Thomas & Betts) "Protect-A-Line"; or equal.

2.06 NAMEPLATES

A. Nameplates are specified in Section 26 05 00

2.07 FIRESTOPS

A. Firestops and seals shall be Flamemastic 77, Vimasco No. 1-A, or equal, and shall be applied in accordance with manufacturer's recommendations. Products which are affected by water are not acceptable.

2.08 RACEWAY IDENTIFICATION

A. Provide raceway numbering as specified in Section 3.06.

B. Raceway number tags:
   1. Solid brass with 0.036-inch minimum thickness.
   2. Raceway number stamped in 3/16-inch minimum height characters
   3. Attached to the raceway with 316 stainless steel wire.

2.09 ELECTRICAL SEALANT

A. Electrical sealant putty shall be non-hardening, non-oxidizing, non-corrosive, non-poisonous, and non-injurious to human skin with service temperature range of 30 to 200 degrees Fahrenheit. Product shall be used to seal against the entrance of water.

2.10 HAZARDOUS AREA AND CORROSIVE AREA CONDUIT SEALS

A. Sealing compound shall be non-hardening type for corrosive areas. Seal fittings for conduit systems in hazardous atmosphere locations shall be hot-dip galvanized cast ferrous alloy or aluminum alloy. Seal fittings shall be 40-percent fill type.

B. Sealing compound shall be hard type installed in UL listed for explosion-proof sealing fittings after the conductors are installed, tested, and accepted.

C. Provide PVC-coated seal fittings used for PVC-coated conduit with 40-mil factory coating. Seal fitting and sealing compound manufacture: Appleton, Crouse-Hinds, or equal.

2.11 PULLING LINE

A. Pulling line shall be polyethylene type, mildew and rot resistant with minimum of 200-pound tensile strength and minimum 1/4-inch diameter. Install in all "future" or "spare" raceways. Manufacture: Greenlee, Ideal, or equal.

2.12 CONDUIT THREAD LUBRICANT

A. Thread lubricant shall be conductive with anti-seize and anti-corrosion properties, compatible with steel and aluminum conduit materials. Manufacture: T&B CP8 KOPR-Shield; Robroy Threadcompound; or equal.

2.13 TERMINAL BLOCKS

1. Terminal blocks are specified in Section 26 05 19.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to Sections 01 61 45 and 26 05 00 for identification of hazardous and corrosive areas.

B. Table A specifies the type of raceway required for each location and application by RACESPEC sheet. Unscheduled conduit shall be galvanized, rigid steel, RACESPEC type GRS.

Table A

Location	Application/Condition	RACESPEC
Indoor noncorrosive	Exposed	GRS
Indoor corrosive	Exposed	PGRS
Outdoor	Exposed	GRS
Concealed	Power circuits embedded in concrete structure or beneath slab-on-grade	PVC4
Concealed	Instrumentation, communications and data signals encased in concrete, duct bank	PVC4
Underground	Power circuits encased in concrete, duct bank	PVC4
Underground	Instrumentation, communications and data signals directly buried	PVC4
Nonhazardous	Final connection to equipment and light fixtures	LFS
Hazardous corrosive	Exposed	PGRS
Hazardous	Final connection to equipment	XPFS
Architecturally finished areas	Concealed in framed walls and ceiling spaces (lighting and receptacle circuits only)	EMT
Architecturally finished areas	Final connection to light fixtures	FLEX

3.02 CONDUIT

A. General:
   1. The conduit systems, installation, and hazardous location fittings are specified herein.

B. Indoor and Outdoor Conduit Systems:
   1. In general, Contractor shall be responsible for determining conduit routing that conforms to the specified installation requirements:
      a. Conduits for lighting and outlets:
      b. exposed
      c. Conduits for process equipment:
      d. exposed
      e. Conduit inside structures:
      f. exposed
      g. Conduit concealed inside water chambers slabs and walls
   2. Conduit installation shall conform to the requirements of the RACESPEC sheets and the following specified installation requirements:
      a. Install exposed conduit parallel or perpendicular to structural members and surfaces. Install conduit horizontally and allow minimum headroom of 7 feet.
      b. Route two or more exposed conduits in the same general routing parallel with symmetrical bends.
      c. Space exposed conduit installed on supports not more than 10 feet apart. Space multiple conduits in parallel and use framing channel.
      d. Comply with the requirements herein, where conduits are suspended from the ceiling.
      e. Secure conduit rack supports to concrete walls and ceilings with cast-in-place anchors or framing channel concrete inserts.
      f. Install conduits at least 6 inches from high temperature piping, ducts, and flues with temperatures higher than 90 degree C.
      g. Install conduits between the reinforcing steel in walls or slabs that have reinforcing in both faces.
      h. Place conduits under the reinforcement in slabs with only a single layer of reinforcing steel. Separation between conduits, conduits and reinforcement, and conduits and surfaces of concrete shall be maintained in accordance with UBC.
      i. Route conduit clear of structural openings and indicated future openings.
      j. Provide conduits with flashed and watertight seals routed through roofs or metal walls.
      k. Grout conduits into openings cut into concrete and masonry structures.
      l. Cap conduits or plug flush conduits during construction to prevent entrance of dirt, trash, and water. Cap or plug empty conduits designated as “future”, “spare”, or “empty” and include a pulling line accessible at both ends. Use anti-seize compound on cap and plug threads prior to installation.
      m. Determine concealed conduit stubup locations from the manufacturer's shop drawings. Terminate concealed conduit for future use in specified equipment.

n. Install conduit flush with structural surfaces with galvanized couplings and plugs. Caps and plugs shall match the conduit system.

o. Provide concealed portions of conduits for future equipment where the drawings indicate future equipment. Match the existing installation for duplicate equipment.

p. Terminate conduits that enter enclosures with fittings that match the NEMA rating of the enclosure.

q. Underground metallic or nonmetallic conduit that turn out of concrete, masonry or earth: Install a 90-degree elbow of PVC-coated rigid steel conduit before emergence above ground.

r. Provide O-Z Gedney "Type DX" or Crouse-Hinds "Type XD" bonded, weathertight expansion and deflection fitting for the conduit size where conduit across structural joints that allows structural movement.

C. Underground Conduit System:

1. Excavation, backfilling, and concrete work shall conform to respective sections of these specifications. Underground conduit shall conform to the following requirements:

a. Underground conduits under roadways or traffic areas that are not shown otherwise on the drawings shall be reinforced concrete encased.

b. Concrete encased conduit shall have minimum concrete thicknesses of 2 inches between conduits, 1 inch between conduit and reinforcing, and 3 inches between reinforcing and earth, unless shown otherwise in an electrical detail.

c. Concrete encasement on exposed outdoor conduit risers shall continue to 3 inches above grade, with top crowned and edges chamfered.

d. Underground conduit bend radius shall be not less than 2 feet minimum at vertical risers and shall be not less than 3 feet elsewhere.

e. Where conduit and concrete encasement are terminated underground, the conduit and reinforcing shall both extend at least 2 feet past the concrete. Conduits shall be capped and threads protected. Steel surfaces shall be given two coats of epoxy paint.

f. Underground conduits and conduit banks shall have 2 feet minimum earth cover unless otherwise shown.

g. Underground conduit banks through building walls shall be cast-in-place or installed with concrete into boxouts with waterstops on all sides of the boxout. Water-stops shall be as specified in the Cast-in-Place Concrete section. Extend the horizontal reinforcement from the duct bank into the boxout terminating with J-hook bends.

h. Conduits not encased in concrete and passing through walls with one side in contact with earth shall be sealed watertight with special rubber gasketed sleeve and joint assemblies or with sleeves and modular rubber sealing elements.

i. Thoroughly swab conduits and raceways on the inside, immediately upon completion of pouring concrete.

j. Label raceways in accordance with 2.08 and 3.05.

k. After the concrete has set and before backfilling, pull a mandrel through each conduit. The mandrel shall have a diameter equal to the nominal conduit inside diameter minus 1/2 inch and shall not be less than 4 inches long.

l. If the mandrel showed signs of protrusions on the inside of the conduit, the conduit shall be repaired or replaced.

m. Provide manufactured plastic conduit spacers anchored to prevent movement during the concrete pour. Manufacture: Carlon, PW Pipe, Underground Devices, or equal.

n. Form the concrete pour ten feet from the wall, manhole, or handhole and form to allow for future conduit entry.

o. Backfill duct banks with clean fill compacted to 90 percent in 6-inch lifts after concrete has cured. Refer to Section 03 30 00 for concrete requirements including minimum 7 days of cure time prior to backfill over duct banks.

p. Allow and provide for two offsets per conduit and raceway for each 100 linear feet to account for unexpected field conditions including for excavation and backfill limited to three feet of extra width and/or depth. Include these specified provisions in the bid price.

q. Provide PVC threaded adapter with female threads where PVC conduit is joined to steel conduit.

r. Procedure:

1) Before assembly: Double coat steel conduit with Red-Robroy, Green-Permacote, Blue-Ocal or equal product.

2) After assembly: Seal with 65-mil thick, 2-inch wide mastic sealing tape to 1/2 inch beyond threads. Procucts: 3M Scotch 2228; Plymouth 02625; or equal.

3) Cover with 20-mil corrosion protection tape applied in ½-lap layers to 2 inch beyond threads. Products: 3M Scotchwrap 51; Plymouth Plywrap 12; or equal.

s. Where reinforced concrete duct banks enter the side of a building, manhole, or handhole and the reinforcement cannot be brought into a window and be terminated, then drill the structure and embed the reinforcement in epoxy to minimum of 3-inches depth.

t. Provide PVC conduit with bell ends where duct banks terminated at walls, manholes, or handholes. Install bell ends flush with finished concrete.

u. Provide PVC conduit with bell ends where conduit rise below grade into a floor mounted electrical panel, electrical cabinet, MCC, switchboard, or switchgear.

v. Separate power conduits from signal conduit within the same ductbank by 12 inches or greater separation, as shown. Refer to the drawings or schedules for signal to be installed in metal conduits instead of PVC ducts.

w. Separate high voltage ductbanks from low voltage ductbanks, as shown.

x. Provide wireways for transition from underslab conduits rising into wall-mounted panels where the number of conduits exceed the NEC allowable panel space in the bottom of the panel. Provide conduit sleeves or fitting for panel transition. Continuous thread or all-thread is prohibited.

D. Conduit In Block Walls

1. Install multiple runs of conduit that stub-up into a block wall and connect to recessed electrical panels with adequate space for the conduit. Coordinated the electrical work with the structural work and block installers to provide a chase to install the conduit. Install conduit in the cells that do not contain structural reinforcement. Install conduits in the center of the cell to avoid affecting the structural integrity of the wall.

2. Avoid conduit and electrical boxes installation that blocks the cell from being grouted or that blocks the cell reinforcing bars from being grouted. Avoid conduit in the first cell adjacent to doors, windows, corners and wall intersections and install conduits in the center of the first available cell a minimum of 1'-0" from the edge of these openings.
3. Where solid grouting of masonry walls is specified, install conduit and electrical boxes so as to provide sufficient space for grout to flow pass the boxes and conduit in order to fully fill the space beneath and behind. Where boxes need to be held in place, secure the boxes from the face of the block wall. Do not place items behind or next to electrical boxes to hold in place.
4. Coordinate split-face, slump and scored block installation with the masonry contractor to supply smooth face block at the location of receptacles and switches so that the device covers install flush to the wall. Install translucent weather-proof sealing material under device covers on outdoor or wet area locations.

E. Conduit Seal-Off Fittings:
1. Conduits passing:
a. Between Class I, Division 1 area and Class I, Division 2 area; provide sealing fittings located at the boundary in accordance with NEC Article-500.
b. From hazardous or corrosive area into a non-hazardous or non-corrosive area.
2. Install the seal-off material in the conduit seal-off fittings after inspection.

F. Conduit And Innerduct Sealing Material:
1. Provide HYDRA-SEAL® Handi-Polyurethane-Foam or equal product to seal conduits and innerducts.
2. Sealing product required features:
a. Compatible with common cable jacket materials.
b. ASTM E-84 flame spread requirements and UL Classified.
c. Pre-pressurized, portable, one-component closed-cell foam sealing system.
d. Dries tack-free within 15 minutes and cures within 24 hours.
e. Reacts with applied moisture or with ambient humidity.
f. Remove over-spray with acetone and remove cured foam mechanically
3. Application Criteria:
a. Apply in ambient temperatures between 60 and 100 degrees Fahrenheit.
b. Apply bead onto clean surface.

G. Conduits in Concrete Construction:
1. Conduits for power, control and instrumentation may be embedded in and pass through concrete construction subject to the limitations in this paragraph. Where concrete strength or serviceability requirements prevent the direct embedment of conduit, provide adequate support, bracing, and serviceability details:
a. Do not impair significantly concrete strength by the embedment of conduits in or through structural sections.
b. Provide conduit layout to the requirements of ACI 318, Sections 3.3 – Aggregates and 6.3 – Conduits and Pipes Embedded in Concrete.
c. Treat conduits similarly to reinforcing steel for purposes of clearance. In general, code sections require conduit spacing the greater of:

d. 1.33 times the maximum concrete aggregate size, clear
    1) Three diameters center to center
    2) Alternate spacing and layout shall be as reviewed and accepted by the Engineer.

2. Conduit and raceway penetrations through walls and slabs where:
    a. one side is a conditioned or an occupied space and the other side not, or
    b. one side has liquid or groundwater contact and the other not,
    c. be detailed and constructed to prevent liquid and moisture penetration through the wall or slab section for each conduit.

3.03 MANHOLES AND HANDHOLES

A. Unless otherwise specified, manhole and handhole installation shall be as follows:
    1. Manholes, handholes, and pull boxes shall be set on a minimum of 6 inches of crushed rock on top of undisturbed or compacted earth.
    2. Manholes and handholes shall be set plumb so that water shall drain to the sump.
    3. Manhole covers shall be 36-inches in diameter and set at 2 inches above finish grade with surrounding pavement sloping away from the manhole cover.
    4. Metallic hardware inside manholes and handholes shall be bonded to the ground plate or ground bus using bolted connections, bonding jumpers and grounding bushings.

B. CABLE RACKS: Cable rack assemblies shall be installed as follows:
    1. Attach rack stanchion to manhole/handhole wall with ½-inch drop-in anchors and ½-x 3/8-inch stainless steel hex head cap screw. Stanchions shall be anchored at the top and bottom of each stanchion as well as above each cable arm.
    2. Provide cable arms to support cables on each rack along the cable run within the manhole/handhole. Provide a minimum of two racks on each wall and two spare cable arms per rack.
    3. Secure each cable or cable bundle to the cable arm with heavy duty, nylon wire ties, Richo WIT-225L or equal. Cable bundles shall be organized by circuit voltage and area served. Multiple circuits may be bundled together where the circuits are derived from the same immediate source and serve the same area. 480 volt AC circuits, No. 6 and larger, shall be individually bundled.

3.04 CABLE TRAY

A. Unless otherwise specified or shown, cable tray installation shall be as follows:
    1. Cable trays shall be supported at intervals not to exceed 5 feet.
    2. Corners shall be supported by two supports installed as close as possible to the corner, with one support on each side of the corner.
    3. Field cuts on steel cable tray shall be treated with zinc rich paint.
    4. Expansion joint splice plates shall be used to allow 1 1/2 inch free movement between adjacent trays when crossing building expansion joint.
    5. Cable tray shall have minimum clearance of 3/4 inch from concrete surfaces and minimum spacing of 12 inches from other trays. The top of the tray shall be minimum 9 inches from the ceiling.

6. Signal cable trays shall be provided with solid type covers.
7. Provide each cable tray with No. 2/0 AWG or No. 4/0 AWG minimum bare copper equipment ground conductor attached to the outside of each tray section using UL Listed bolted bronze or brass ground clamp and bond to the ground grid system.
8. Power cables shall be placed in cable trays in accordance with the NEC.
9. Cables shall be arranged in trays for minimum cross-over for entry or exit.
10. Provide cable tray barrier between power and control cables, if not in separate cable trays.
11. Provide cable tray barrier between control and instrument cable in the same cable tray.

3.05 RACEWAY NUMBERING

A. Each new and reused conduit shall be provided with a number tag at each end and in each manhole, handhole, or pull box. Cable trays shall be identified by stencils at intervals not exceeding 50 feet, at intersections, and at each end to identify power cable tray voltage, control cable tray, or instrument cable tray.

B. Raceway Numbers:
   1. Tag raceways at all terminations. Raceway numbers will comply with raceway labels assigned on the drawings. Where raceway numbers have not been assigned, assign raceway numbers in accordance with the following system:

Raceway Prefix	Type of Function
RC	Control or power - 120V or less
RH	Power above 600V
RN	Pneumatic tubing
RP	Power 208V to 600V
RS	Signal - data communication or instrumentation
RX	Spare

   2. Provide number after the prefixes . Add a letter suffix to distinguish the raceways where more than one raceway is routed to a particular piece of equipment. Example: Raceway number = P3109A where:
      a. RP = conduit contains power
      b. 50CV30051 = equipment number
      c. A = letter to distinguish raceways to same equipment

C.

3.06 RACEWAY SCHEDULE

A. General:
   1. The Raceway Schedule is included in Section 26 06 20.23.

B. Unscheduled Raceway:
   1. With the exception of lighting, communication, paging, fire alarm, security and receptacle circuits, the type and size of raceway shall be as specified on the drawings or schedules.

2. Unscheduled lighting and receptacle raceways shall be sized by the Contractor in accordance with the NEC. Minimum size shall be 3/4 inch for exposed and 1 inch for embedded raceway.
3. The number and size of communication, paging, fire alarm, and security raceways shall be as required for the particular equipment provided subject to the minimum sizes specified herein.

C. Scheduled Raceway:
1. The size and type of raceway shall be as specified on the schedules.

D. RACESPEC Sheets
1. The following RACESPECS are included in this section:
a. EMT
b. FLEX
c. GRS
d. LFS
e. PGRS
f. LFS
g. PVC4
h. PVC8
i. TRAY

3.07 RACEWAY SPECIFICATION SHEETS (RACESPEC) - EMT– EMT

A. Raceway Identification:
1. EMT

B. Description:
1. Electrical Metallic Tubing

C. Compliance:
1. ANSI and UL

D. Finish:
1. Electro-galvanized steel

E. Minimum size:
1. 3/4 inch

F. Fittings:
1. Compression type.
2. Fittings inside concrete block (CMU) walls:
a. Concrete-tight.

G. Boxes:
1. Electro-galvanized sheet steel.

2. NEMA Class 1 stamped or form-bent steel with screw covers.

3.08 RACEWAY SPECIFICATION SHEETS (RACESPEC) – FLEX

A. Raceway Identification:
   1. FLEX

B. Description:
   1. Flexible Steel Conduit

C. Application:
   1. Final connection to equipment subject to vibration or adjustment.

D. Compliance:
   1. UL 1

E. Construction:
   1. Spirally wound galvanized steel strip with successive convolutions securely interlocked.

F. Minimum Size:
   1. 1/2 inch

G. Fittings:
   1. Compression type

H. Other:
   1. FLEX shall be provided with an internal ground wire.

3.09 RACEWAY SPECIFICATION SHEETS (RACESPEC) – GRS

A. Raceway Identification:
   1. GRS

B. Description:
   1. Galvanized Rigid Steel Conduit (GRS)

C. Compliance:
   1. ANSI and UL

D. Finish:
   1. Hot-dip galvanized after fabrication, inside and outside. Smooth finished surfaces.

E. Manufacturers:
   1. Allied Tube and Conduit Corp., Wheatland Tube Co., or equal.

F. Minimum size:
   1. Unless otherwise specified, 3/4 inch for exposed, 1 inch for embedded, encased, or otherwise inaccessible.

G. Fittings:
   1. Locknuts, Rings, Hubs:
      a. Hot-dip galvanized insulated throat with bonding locknut or ring,. The hubs shall utilize a neoprene "O" ring and provide a watertight connection. O-Z Gedney, CHM-XXT, or equal
   2. Unions:
      a. Electro-galvanized ferrous alloy type Appleton UNF or UNY, Crouse-Hinds UNF or UNY, or equal. Threadless fittings are not acceptable.
   3. Conduit Bodies:
      a. Oversized conduit bodies: Ferrous alloy type with screw taps for fastening covers to match the conduit system. Gaskets shall be made of neoprene.

H. Boxes:
   1. Indoor:
      a. Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
   2. Outdoor:
      a. Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
   3. Corrosive:
      a. NEMA 4X stainless steel or nonmetallic, as specified.
   4. Hazardous:
      a. NEMA Class 7 cast ferrous.

I. Elbows:
   1. 3/4" thru 1-1/2" –- Factory fabricated or field bent.
   2. 2" thru 6" –- Factory fabricated only.

J. Conduit Bodies (Oversized):
   1. 3/4" thru 4" –- Malleable iron, hot-dip galvanized, unless otherwise noted. Neoprene gaskets for all access plates. Tapered threads for conduit entrances.
   2. 5" and 6" –- Electro-galvanized iron or cast iron box.

K. Expansion Fittings:
   1. Expansion fittings in embedded runs shall be watertight with an internal bonding jumper. The expansion material shall be neoprene allowing for 3/4-inch movement in any direction.

L. Manufacturers:
   1. Appleton, Crouse-Hinds, Hubbell, O. Z. Gedney, or equal.

M. Installation:
   1. Rigid steel conduit shall be made up tight and with conductive thread compound. Joints shall be made with standard couplings or threaded unions. Steel conduit shall be supported away from the structures using hot-dip galvanized malleable iron straps with nesting backs or framing channel.

2. Conduit entering boxes shall be terminated with a threaded hub with a grounding bushing.
3. Exposed male threads on rigid steel conduit shall be coated with zinc-rich paint.

3.10 RACEWAY SPECIFICATION SHEETS (RACESPEC) – LFS

A. Raceway Identification:
   1. LFS

B. Description:
   1. Liquidtight Flexible Steel Conduit

C. Application:
   1. Final connection to equipment subject to vibration or adjustment.

D. Compliance:
   1. UL 360

E. Construction:
   1. Spirally wound galvanized steel strip with successive convolutions securely interlocked and jacketed with liquidtight plastic cover.

F. Minimum Size:
   1. 3/4 inch

G. Fittings:
   1. Cadmium-plated malleable iron body and gland nut with cast-in lug, brass grounding ferrule threaded to engage conduit spiral.
   2. O-ring seals around the conduit and box connection and insulated throat.
   3. Provide forty-five and ninety degree fittings where applicable.
   4. Provide PVC coated flexible conduit and fittings where the conduit system is PVC coated.

H. Installation:
   1. Length of flexible liquidtight conduit shall not exceed 15 times the trade diameter of the conduit and not exceed 36 inches in length. Use conductive thread compound.

3.11 RACEWAY SPECIFICATION SHEETS (RACESPEC) –- PGRS

A. Raceway Identification:
   1. PGRS

B. Description:
   1. Rigid Steel Conduit, Corrosion-Resistant, Polyvinyl Chloride (PVC) Coated.
   2. Provide factory made and coated elbows.

C. Compliance:
   1. ANSI, ETL and UL. The PVC coated rigid galvanized steel conduit shall be stamped with the ETL Verification Mark “ETL Verified to PVC-001”.

D. Finish:
   1. PGRS shall be hot-dip galvanized rigid steel conduit as specified in Section 26 05 33- paragraph 3.03 GRS, with a PVC Coating. The PVC coating shall be gray, minimum 40 mils thick, bonded to the outside and continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles, or pinholes. Thread protectors shall be used on the exposed threads of the PVC coated conduit.
   2. A 2-mil coat of urethane enamel coating shall be bonded to the inside. Coating shall be free of pinholes. Bond strength shall exceed the tensile strength of the PVC coat.

E. Minimum Size:
   1. 3/4 inch

F. Fittings:
   1. Similarly coated to the same thickness as the conduit and provided with Type 316 stainless steel hardware. Conduit and fittings shall be manufactured by the same company Conduit and fittings shall be coated by the same company. Male threads on elbows and nipples, and female threads on fittings or conduit couplings shall be protected by application of urethane coating.

G. Covers:
   1. PVC coated covers shall have V-groove seal and stainless steel hardware.

H. Hubs:
   1. Hubs for connection of conduit to junction, device, or terminal boxes shall be threaded cast ferrous alloy.
   2. Hubs shall have the same PVC coating as the conduit and insulating grounding bushings. Hubs shall utilize a neoprene "O" ring and shall provide a watertight connection.

I. Boxes:
   1. Nonhazardous:
      a. NEMA Class 4X stainless steel or nonmetallic.
   2. Hazardous:
      a. NEMA Class 7 cast ferrous.

J. Manufacturers:
   1. PVC coated conduit that bears the ETL Verified PVC-001 label by Robroy Industries, Plasti-Bond, Perma-Cote, KorKap or equal.

K. Installation:
   1. Plastic coated conduit shall be made up tight, threaded, and installed using tools approved by the PVC-coated conduit manufacturer.
   2. Exposed conduit threads shall be covered by a plastic overlap coated and sealed per manufacturer’s recommendations.

3. Pipe wrenches and channel locks shall not be used for tightening plastic coated conduits. Damaged areas shall be patched, using manufacturer's recommended material. The area to be patched shall be built up to the full thickness of the coating. Painted fittings are not acceptable.
4. PVC coated conduit shall be supported away from the structure using PVC coated conduit wall hangers or PVC coated conduit mounting hardware.
5. Damaged work shall be replaced

L. Training:
1. Installers shall be trained and certified in the proper installation techniques provided by the PVC-coated conduit system manufacture. Proof of certification shall be provided under paragraph 1.03.

3.12 RACEWAY SPECIFICATION SHEETS (RACESPEC) – PVC4

A. Raceway Identification:
1. PVC4

B. Description:
1. Rigid Nonmetallic Conduit.

C. Application:
1. Heavy wall thickness for direct bury, concrete encasement or surface mounting where not subject to physical damage.

D. Compliance:
1. NEMA TC2, UL 651

E. Construction:
1. Schedule 40, high-impact, polyvinylchloride (PVC)

F. Minimum size:
1. 3/4 inch exposed; 1 inch embedded or encased

G. Fittings:
1. PVC solvent weld type

H. Boxes:
1. Indoor:
   a. NEMA Class 4, nonmetallic
2. Outdoor and corrosive:
   a. NEMA Class 4X, nonmetallic

I. Installation:
1. PVC conduit entering fiberglass boxes or cabinets shall be secured by threaded bushings on the interior of the box and shall be terminated with a threaded male terminal adapter having a neoprene O ring.
2. Joints shall be made with standard PVC couplings.

3. PVC conduit shall have bell ends where terminated at walls and boxes.

3.13 RACEWAY SPECIFICATION SHEETS (RACESPEC) – PVC8

A. Raceway Identification:
   1. PVC8

B. Description:
   1. Rigid Nonmetallic Conduit

C. Application:
   1. Extra heavy wall thickness for locations including direct bury under roadways where not exposed to traffic damage and surface mounted in corrosive areas.

D. Compliance:
   1. NEMA TC2, UL 651

E. Construction:
   1. Schedule 80, high-impact, polyvinylchloride (PVC)

F. Minimum Size:
   1. 3/4 inch exposed; 1 inch embedded or encased

G. Fittings:
   1. PVC solvent weld type

H. Boxes:
   1. Indoor:
      a. NEMA Class 4X, nonmetallic
   2. Outdoor and corrosive:
      a. NEMA Class 4X, nonmetallic

I. Installation:
   1. Exposed PVC conduit shall be run on supports spaced:
      a. 3 feet apart for conduits up to 1 inch.
      b. 5 feet apart for conduits 1-1/4 inches to 2 inches.
      c. 6 feet apart for conduits 2 1/2 inches and larger.
      d. PVC conduit not provided where damaged by heat.
      e. eBell ends where terminated at walls, boxes and electrical cabinets and control panels.

3.14 RACEWAY SPECIFICATION SHEETS (RACESPEC) – TRAY

A. Raceway Identification:
   1. TRAY

3.15 TRAY

A. Description:
   1. Cable Tray: Ladder type with rungs and side rails.
   2. Cable Tray Covers: No
   3. Bottom to side rail connections shall be positive mechanical joints to assure lateral and longitudinal stability.
   4. Steel:
      a. Pre-Galvanized, ASTM-A-924, indoor.
   5. Steel:
      a. Hot Dip Galvanized post fabrication, ASTM-123, outdoor.
   6. Stainless Steel:
      a. Type 304 per ASTM-A-240.
   7. Aluminum:
      a. AA-6063-T6.

B. Application:
   1. As shown on the drawings.

C. Compliance:
   1. NEMA VE-1

D. Loading and Deflection Requirements:
   1. The trays shall be designed and constructed to support a uniformly distributed load when tested as a single span, simple beam:

NEMA Load/Span Designation:

Class	Support Span Feet	Working Load (lbs/linear feet)
8A	8	50
8B	8	75
8C	8	100
12A	12	50
12B	12	75
12C	12	100
16A	16	50
16B	16	75
16C	16	100
20A	20	50
20B	20	75
20C	20	100

E. Dimensions:
   1. Width and depth shall be as specified or shown.

Width	Loading Depth (lbs/linear feet)			
(inch)	3”	4”	5”	6”
6	22	29	36	44
12	44	58	72	88
18	65	87	108	130
24	88	116	144	175
30	108	144	180	216
36	130	174	216	260

F. Finish:
   1. For steel cable tray:
   2. Hot-dip galvanized after fabrication with smooth finished surfaces.

G. Accessories:
   1. Fittings, barriers and covers shall be of the same materials, finish and construction as the straight tray products.

END OF SECTION

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SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. SCOPE: This Section covers the furnishing and installation of cable trays. Cable trays shall be provided where shown on the Drawings, for lighting, receptacles, power, control, instrumentation, signaling and grounding systems. Fire alarm circuits may not be run in cable tray. For Communication systems see Section 27 05 36.

1.02 QUALITY ASSURANCE

A. REFERENCE STANDARDS:

1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
NEMA VE 1-1998	Metallic Cable Tray Systems
NEMA VE 2-2000	Cable Tray Installation Guidelines
NFPA 70	National Electrical Code (NEC)
UL	Underwriters Laboratories, Inc.
IBC	International Building Code

B. SHIPMENT AND STORAGE:

1. Materials and equipment shall be stored in a manner to keep them dry and clean. Equipment and materials to be located indoors shall be stored indoors and sealed with plastic film wrap. Electrical and electronic equipment found stored or staged outdoors over night or in inclement weather shall be considered grounds for equipment rejection and shall be replaced at Contractor's expense

1.03 SUBMITTALS

A. PROCEDURES: Section 01 33 00.

B. ACTION SUBMITTAL ITEMS FOR THIS SECTION:

1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.

2. Catalog cuts of equipment, devices, and materials installed under this section. Catalog information shall include technical specifications and application information, including electrical ratings, dimensions, weight, etc. Catalog cuts shall be edited to show only the items, model numbers, and information which apply.

1.04 DESIGN OF CABLE TRAY SYSTEMS

A. GENERAL: The tray system layout may be coordinated with the piping submittals to reflect the coordination of the layout of these systems. The professional engineering services for the piping systems may provide the engineering services for cable trays structural supports called for in this Section.

B. PROCEDURES: In addition to materials and labor required to construct cable tray systems, Contractor shall provide professional engineering services ("design professional") for the design and inspection of cable tray systems work. The Contractor shall provide the final design, inspection, and certification for the tray supports and seismic restraints on this project meeting the requirements of specification section 01 73 24.

C. QUALIFICATIONS: The design of tray supports and seismic restraints shall be the product of a professional engineer retained by the Contractor and currently licensed to practice in the state of Washington. The design professional shall have not less than five years experience in the type of cable tray support, and seismic restraint design work required for this project. This requirement, however, shall not be construed as relieving the Contractor of overall responsibility for this portion of the work. Documentation demonstrating qualifications and insurance shall be submitted.

D. Coordination with Drawings and Specifications: If a particular type of support, anchor, seismic restraint, or expansion element is detailed on the Drawings, those elements shall be incorporated into the Contractor's design. Cable tray system submittals by the Contractor shall include all elements, including unscheduled trays.

E. Coordination with Cable Installation Requirements: The tray system design shall be coordinated with the cable installation means to insure that the cables can be installed without exceeding the cable manufacturer's limits for pulling tensions, sidewall pressures and minimum bending radii.

F. Usage for Unscheduled Cables:
   1. Unscheduled cables are those that are required per the specifications but are not listed in the cable schedules. See Section 26 05 19 for further description of unscheduled cables.
   2. Only multi-conductor type cables shall be used in cable trays.
   3. Any unscheduled wiring to be installed in trays must meet Section 26 05 19 requirements for cables in trays and must be submitted for review by the Owner. Review submittal shall include revised cable tray schedule and fill calculations.
   4. The Contractor shall assume that scheduled cable trays have 25 percent of their total available NEC capacity available for use for unscheduled wiring. **No tray shall be filled to more than 75 percent of its maximum allowable capacity including scheduled and unscheduled cables.**

5. The Contractor may partition trays to create space for cabling that needs to be partitioned per the NEC under the following conditions:
    a. The partitioned spaces leave at least 50 percent capacity for future cables in each partitioned space.
    b. A tray shall not have more than two partitioned spaces.
    c. The tray partitions are submitted for review and approved by the Owner.
    d. Tray transitions “over-passes” are included in the installation.
6. Contractor shall provide wider trays than those scheduled in the specified tray schedules when the desired usage for unscheduled wiring exceeds the allowable capacity for existing tray sizes in the trays schedules. Wider trays shall be submitted for review along with documentation that verifies that they do not exceed 75 percent of maximum allowable tray capacity and that the wider trays do not adversely impact the accessibility and clearance to and around trays and to other equipment or systems.
7. Contractor shall provide marked up cable and tray schedules reflecting the circuits added to the trays.
8. Lighting panel circuits for lights and receptacles can be installed in CTP trays as multi-conductor cables.
9. HVAC Division 23 controls and signals wiring can be installed in trays per the following:
    a. 24V and 120V controls wiring can be installed in the CTC trays if the control circuits are Class 1 remote control and signaling rated, and armored multi-conductor wiring is used, that meets the specified requirements of Division 26.
    b. HVAC communications wiring can be installed in the CTS trays if the circuits are Class 2 rated and armored multi-conductor cabling is used that meets the specified requirements of Section 26 05 23.
10. Unscheduled cabling for other systems shall be in accordance with the above requirements and the guidelines specified in Section 26 05 19.

PART 2 PRODUCTS

2.01 CANDIDATE MANUFACTURERS/PRODUCTS

A. Candidate manufacturers and models are listed below. To conform with specified requirements, the manufacturer’s standard product may require modification.
    1. Cooper B-Line
    2. MP Husky
    3. Cablofil
    4. Approved Equal

2.02 GENERAL

A. CABLE TRAY SECTIONS AND COMPONENTS:
    1. Cable tray systems are defined to include, but are not limited to straight sections of ladder type cable trays, bends, tees, elbows, trough drop-outs, barriers, clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, fittings, supports and accessories.

2. Provide aluminum cable trays, of types, classes, and sizes indicated; with splice plates, bolts, nuts and washers for connecting units. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards. Cable tray shall be installed according to the latest revision of NEMA VE-2.

B. TYPE OF TRAY SYSTEM:
   1. Cable Trays specified in RACESPEC category CT shall be ladder type and shall consist of two 6 inch tall longitudinal members (side rails) with transverse members (rungs) mechanically fastened to the side rails. Rungs shall be spaced 6 inches on center. Rung spacing in radiused fittings shall be industry standard 9" and measured at the center of the tray's width. Rungs shall be capable of easy removal, reinstallation, or replacement if necessary.
   2. Cable tray loading depth shall be 5 inches per NEMA VE-1.
   3. Straight sections shall be supplied in standard 10 foot (3 meters) lengths.
   4. Cable tray widths shall be 12, 24, and 36 inches as shown on drawings.
   5. Splice plates shall have 4 nuts and bolts per plate. The resistance of fixed splice connections between adjacent sections of tray shall not exceed 0.00033 ohms. Splice plates shall be furnished with straight sections and fittings.
   6. All fittings shall have a minimum radius of 12 inches.

C. CENTERRAIL TRAY SYSTEM: Cable Trays specified in RACESPEC category CTCR shall be constructed of a main single center rail with single rungs attached to the center rail as specified in RACESPEC CTCR. Refer to standard details for application and use.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cable trays shall be supported at intervals not to exceed 5 feet.

B. Corners shall be supported by two supports installed as close as possible to the corner, with one support on each side of the corner.

C. All field cuts shall be treated with zinc rich paint.

D. Expansion joint splice plates shall be used to allow 1-1/2-inch free movement between adjacent trays when crossing building expansion joint.

E. Cable tray shall have minimum clearance of 3/4 inch from concrete surfaces and minimum spacing of 12 inches from other trays. The top of the tray shall be minimum 9 inches from the ceiling.

F. Each cable tray shall be grounded per 26 05 26. The ground conductor shall be attached to the outside of each tray section using UL Listed bolted bronze or brass ground clamp.

G. Cables shall be arranged in trays so as to provide minimum cross-over.

H. When required, and to provide an area free of center rails for cable transitions, contractor shall install a universal fitting. The universal fitting, B-Line U6A-xx Series, which can be used with cable ties and allows the rails to be connected so that they may be pivoted at connection points.

I. Ensure center-supported cable tray will withstand any off-balanced loading that may be created when installing cables. Follow cable tray manufacturer's recommendations on stabilizing methods.

J. Non-armored, CT rated cables shall transition from tray to conduit via listed cable tray conduit clamps, Cooper LCC Series or equal.

3.02 NUMBERING

A. Cable trays shall be identified by stencils at intervals not exceeding 50 feet, at intersections, and at each end.

3.03 TESTING

A. In addition to any testing herein, perform all testing for this product or system consistent with the requirements of Section 26 08 00, the applicable codes, and the manufacturers' current quality assurance program.

B. Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. See NFPA 70B for testing and test methods.

C. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1; including test reports verifying rung load capacity in accordance with NEMA VE-1 Section 5.4.

3.04 CABLE TRAY SUPPORT INSPECTION

A. The Contractor shall cause the design professional retained under the provisions of this Section to inspect the installation of the cable tray supports and seismic restraints provided under this Contract. The design professional shall be at the site of the work during the installation work and shall provide the Owner with weekly reports indicating progress of the work.

B. The Owner will provide special inspection in accordance with Section 01 45 33 for certain cable tray seismic anchorage and bracing systems as shown on the Drawings.

C. Upon completion of construction, but prior to beneficial occupancy of the cable tray systems by the Owner, the design professional shall conduct a detailed final inspection and furnish the Owner with a final report certifying, without qualification, that all work has been accomplished in accordance with applicable requirements. All reports shall bear the design professional's seal and signature in accordance with the laws, rules, and regulations of the regulatory authority.

3.05 RACESPEC SHEETS

A. The following RACESPECS are included in this section:
   1. CT - Ladder Cable Tray
   2. CTCR – Low Voltage Information Technology Tray

3.05 RACEWAY SPECIFICATION SHEETS (RACESPEC)

Raceway Identification:	CT
Description:	Cable Tray
Compliance:	NEMA VE-1, 20B, 16C
Loading and deflection requirements	The tray system shall be designed and constructed to support a uniformly distributed load of 50 pounds per linear foot with a maximum deflection of 0.57 inch when tested as a single 10 foot span, simple beam. The NEMA VE-1, 20B, 16 thickness shall be maintained to ensure that the system is rigid against impact velocity (wind loading) and aerodynamic effects on the tray.
Finish:	Copper-free aluminum, Alloy 6063-T-6 (side rails, rungs and splice plates), Alloy 5052-H32 (covers and accessories except where 316 Stainless Steel is specified)
Manufacturers:	Cooper, B-Line Series 35, Burndy, Globe
Size:	5-inch minimum interior depth. 6-inch outside height. Rung spacing shall be 6-inch.
Fittings:	Splice plates, elbows, risers, tees, crosses, Y, reducer plates, blind ends, barrier strips, radiused dropouts, divider strips coated with the same finish as the cable tray. Where the cable exits the tray over the edge a cushioned conduit strap or clamp shall be used. Superstrut A-716 or U716 series, or equal. Where the cable requires vertical support in tray, a cushioned conduit strap shall be used. Superstrut A-716 series, or equal. Miscellaneous fittings and accessories shall be as provided as required. These fittings and accessories are shown in the cable tray manufacturer catalog. Fittings, when not available in aluminum, shall be 316L S.S.
Barrier	Separate the power cables, control, and signal cables where shown in the drawings. Barriers shall be manufactured with copper-free aluminum, Alloy 6063-T-6

3.05 RACEWAY SPECIFICATION SHEETS (RACESPEC)

Raceway Identification:	CT (continued)
Cover:	Where shown on drawings, provide ventilated flanged covers (B-Line 81-7-A-40-xx—xx, or equal) for all trays, use heavy duty wrap around clamps. Provide three clamps per cover. The threaded fasteners shall be treated with a resin that is specifically design to prevent the nut from working loose due to vibration, such as Loctite 242, Blue, or equal. The covers shall be overlapped at expansion joints to eliminate cover buckling. Where tray covers do not line up such as around the digester, provide field shaped flashing made out of marine-grade aluminum to cover the gap so that the cable is protected from the weather. Rivet the flashing in place.
Cable tray hold-down clamps:	316L stainless steel
Installation:	The cable tray shall be installed in accordance with the manufacture's instructions and the Cable Tray Manual as published by Cooper B-Line that is based on the latest edition of the National Electrical Code. Cable shall be fastened to the cable tray rungs every 6 feet and on both side of the turns with UV resistant plastic ties. Cables shall be supported on the vertical runs so that the weight of the cable is distributed throughout the run and not at the bend from horizontal. Appropriate cable clamps shall be used to securely fasten each cable to the cable tray. The cable shall exit the bottom of the covered tray and shall be supported an appropriate conduit fitting. Where the cable tray is installed around the perimeter of the digester, the contractor shall install short straight pieces (less than 10 foot long) of tray connected together with horizontal adjustable splice plates (B-Line Series 9A-103 or equal) to curve around the perimeter of the digester.

3.05 RACEWAY SPECIFICATION SHEETS (RACESPEC)

Raceway Identification:	CT (continued)
Grounding:	The cable tray have an equipment grounding conductor installed the entire length of the tray. The equipment grounding conductor shall be a bare #2/0 AWG copper conductor. The conductor shall be grounded to alternate sections of cable tray using a tin or zinc-plated ground clamp. The copper connection shall be coated with a joint compound such as Pentox "A" (Burndy) and Alnox (Alcoa). The tray grounding conductor shall be attached to the tray using a cable tray grounding conductor clamp. Appleton Type TCGC (or equal). Bonding jumpers shall be provided at expansion joints, discontinuities, and around adjustable splice plates.

3.05 RACEWAY SPECIFICATION SHEETS (RACESPEC)

Raceway Identification:	CTCR
Description:	Center Rail Power and Signal Cable Tray
Compliance:	NEMA VE-1, 20B, 16C
Loading and deflection requirements	The tray system shall be designed and constructed to support a uniformly distributed load of 50 pounds per linear foot with a maximum deflection of 0.57 inch when tested as a single 10 foot span, simple beam. The NEMA VE-1, 20B, 16 thickness shall be maintained to ensure that the system is rigid against impact velocity (wind loading) and aerodynamic effects on the tray.
Construction:	Cable trays shall be constructed of a center rail 1.625 x 3.250 inches with minimum section properties of Sx = 0.701 in^3 and Ix = 1.174 in^4. Rungs shall be a single continuous square tube 0.54 x 0.54 inches with radiused corners and minimum section properties of Sx = 0.019 in^3 and Ix = 0.005 in^4. Rungs shall be mechanically connected to the center rail in at least two places, symmetrical about the center rail, with ends finished to protect installers and cables.
Materials and Finish:	Aluminum: Center rails and rungs shall be extruded from Aluminum Association Alloy 6063. All fabricated parts shall be made from Aluminum Association Alloy 5052. All hardware and fasteners shall be zinc-plated steel in accordance with ASTM B633)
Manufacturers:	Cooper, B-Line Centerline Series , Data Rack; Cablofil Center Spine; Burndy; Globe.
Size:	5-inch minimum interior depth. 6-inch outside height. Rung spacing shall be 6-inch.
Fittings:	Splice plates, elbows, risers, tees, crosses, Y, reducer plates, blind ends, barrier strips, radiused dropouts, divider strips coated with the same finish as the cable tray. Where the cable exits the tray over the edge a cushioned conduit strap or clamp shall be used. Superstrut A-716 or U716 series, or equal. Where the cable requires vertical support in tray, a cushioned conduit strap shall be used. Superstrut A-716 series, or equal.

3.05 RACEWAY SPECIFICATION SHEETS (RACESPEC)

Raceway Identification:	CTCR (continued)
	Miscellaneous fittings and accessories shall be as provided as required. These fittings and accessories are shown in the cable tray manufacturer catalog. Fittings, when not available in aluminum, shall be 316L S.S.
	All splices and connectors must protect cables from the edges of the center rail and act as a barrier to prevent the center rail from transmitting hazardous gases or smoke; hardware must be installed vertically so as not to interfere with the cables in the cable fill area.

END OF SECTION

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SECTION 26 05 74

ARC FLASH HAZARD ANALYSIS, SHORT CIRCUIT STUDY

AND PROTECTIVE DEVICE COORDINATION REPORT

PART 1 GENERAL

1.01 DESCRIPTION

A. General:
   1. This section specifies that the Contractor subcontract an independent full member NETA Engineering and Study Firm / Testing Firm to prepare:
      a. Electrical equipment short circuit study (SCS) all facility new and existing equipment.
      b. Existing equipment includes:
         1) Operations Building Transfer switch and MCC
         2) Clarifier Electrical Panels
      c. Protective device coordination study (PDCS) report for all equipment in the treatment building electrical distribution power system.
      d. Arc flash hazard analysis (AFHA) and labeling for the new equipment being installed.

B. The Testing Firm shall be as described in Section 26 08 00 and shall also be responsible for the electrical testing described therein.

C. Scope:
   1. The Short Circuit and Protective Device Coordination Report shall include analysis including Utility Company equipment that affect the installed equipment's short circuit ratings, protective device ratings and protective device settings.
   2. Report shall also include analysis of the equipment's short circuit ratings, protective device ratings and protective device settings affected by the installed equipment.
   3. Report shall include the results of the arc flash hazard analysis study for energized electrical equipment in accordance with the methods outlined in IEEE Standard 1584 and stated hereinafter.
   4. Work shall include the fabrication of warning labels with the arc flash hazard analysis results and the installation of the labels on the equipment in accordance with NFPA 70E Article 130.5 that includes nominal system voltage, arc flash boundary, and at least one of the following: Available incident energy and corresponding working distance or the arc flash personnel protective equipment (PPE) level but not both, the minimum arc rating of clothing, site specific level of PPE.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 141	Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
NETA ATS	Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
NFPA 70E	Standard for Electrical Safety in the Workplace
NFPA 70	National Electrical Code

1.03 SCHEDULE

A. The report shall be completed, submitted to the Construction Manager for acceptance and reworked to include the Construction Manager comments and corrections, as required. The report shall be approved by the Construction Manager prior to purchase and fabrication of electrical equipment including switchgear.

B. A copy of the Construction Manager accepted report shall be sent by the Contractor to all affected manufacturers prior to fabrication.

1.04 SUBMITTALS

A. The report specified in this Section shall be provided in accordance with Section 01 33 00.

PART 2 PRODUCTS

2.01 REPORT

A. The product shall be a certified report summarizing the short circuit and coordination study and conclusions or recommendations which may affect the integrity of the electric power distribution system. As a minimum, the report shall include the following:
   1. The equipment manufacturer's information used to prepare the study.
   2. Power Utility Company system information applicable to the project.
   3. Short circuit calculations listing short circuit levels at each bus. Provide a sketch of the bus and use both the project term and the bus-code-name to identify the bus, branches, sources, loads. Base the system on the Project One-Line diagram.
   4. Coordination study time-current curves including the instrument transformer ratios, model numbers of the protective relays, and the relay settings associated with each breaker.

5. Comparison of short circuit duties of each bus to the interrupting capacity of the equipment protecting that bus.
6. Data used as input to the report that includes cable impedances, source impedances, equipment ratings for the equipment being purchased for the project, etc.
7. Arc flash hazard calculations listing incident energy levels at each bus.
8. Copy of the Arc flash warning labels displaying information in accordance with NFPA 70e requirements.
9. Assumptions made during the study.

PART 3 EXECUTION

3.01 GENERAL

A. Provide a short circuit and coordination study on the electrical power distribution system as specified and as described in Section 6.1 of NETA ATS. The studies shall be performed in accordance with IEEE Standards 141 and 242 and shall utilize the ANSI method of short circuit analysis in accordance with ANSI C37.010.

B. The studies shall be performed using actual equipment data for both existing and new equipment. The coordination study shall use the data from the same manufacturer of protective relay devices as being provided by the switchgear manufacturer.

C. For new equipment, the Contractor shall provide copies of final reviewed equipment submittals upon request by the Study Firm.

D. For existing equipment, the Study Firm shall provide three separate one man-day trips of onsite investigation to identify loads and power distribution equipment data.

E. Any power distribution equipment outages shall be scheduled in advance and coordinated with the Owner to limit process outages as required per plant process capacities, refer to Section 01 14 19 and Section 26 05 00.

3.02 QUALIFICATIONS

A. The short circuit and coordination report shall be performed by the Study Firm/ Testing Firm as described in Section 26 08 00. The studies shall be signed by the professional electrical engineer responsible for the studies and registered to practice engineering in the state in which the project is located.

3.03 SHORT CIRCUIT STUDY

A. The Contractor shall be responsible to obtain and verify all data needed to perform the study. As a minimum, the short circuit study shall include the following:
   1. One-Line Diagram
      a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.

c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
d. Type, manufacturer, and ratio of all instrument transformers energizing each relay.
e. Nameplate ratings of all motors and generators with their subtransient reactances. Transient reactances of synchronous motors and generators and synchronous reactances of all generators.
f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
g. circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
h. Emergency as well as normal switching conditions, as applicable.
i. The time-current setting of existing adjustable relays and direct-acting trips, as applicable.

B. Calculations
1. Determine the paths and situations where short circuit currents are the greatest.
2. Study shall address bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
3. Calculate the maximum and minimum fault currents.

3.04 ARC FLASH HAZARD ANALYSIS

A. The Contractor shall be responsible to obtain and verify all data needed to perform the study. The arc flash analysis study shall include the following IEEE Standard 1584 nine step analysis process:
1. Collect system and installation data.
2. Determine modes of operation.
3. Determine bolted fault current.
4. Determine arc fault current.
5. Determine protective device characteristic and arc fault duration.
6. Document system voltages and equipment class.
7. Select working distances.
8. Calculate incident energy.
9. Calculate the arc flash protection boundary.

3.05 PROTECTIVE DEVICE COORDINATION STUDY

A. As a minimum, the coordination study for the power distribution system shall include the following on 5-cycle, log-log graph paper:
1. Time-current for each protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified, and the complete protective relay settings shall be specified.
2. Time-current curves for each device shall be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the Construction Manager shall be notified as to the cause.
3. Time-current curves and points for cable and equipment damage.

4. Circuit interrupting device operating and interrupting times.
5. Indicate maximum fault values on the graph.
6. Sketch of bus and breaker arrangement.

3.06 IMPLEMENTING PDCS SETTINGS AND ARC FLASH SIGN INSTALLATION

A. The Study Firm/Testing Firm shall work with the Contractor to implement the protective device coordination study settings on new and existing equipment as required in Section 26 08 00, based on the Engineers accepted Protective Device Coordination Report specified herein and submit a final amended report of the Record As-Built electrical equipment protective device settings subsequent to start-up and testing.

B. The Study Firm/Testing Firm shall work with the Contractor for implementing the Arc Flash Hazard warning labels installation requirements for electrical equipment as specified in NEC Article 110.16 Arc-Flash Hazard Warning , and NFPA 70E requirements.

END OF SECTION

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SECTION 26 06 20.23

ELECTRICAL CIRCUIT SCHEDULE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies the raceway schedule for conduits, wireways, and cable trays specified in Section 26 05 33.

B. Definitions:
   1. The raceway schedule contains the following information:
      a. Raceway Number:
         1) A unique number assigned to a single raceway.
      b. From and To:
         1) The equipment designations at which the raceway ends are terminated.
      c. Type:
         1) Type of raceway defined by the RACESPEC sheets and specified in Section 26 05 33.
      d. Size:
         1) Nominal trade size of raceway.
      e. Voltage:
         1) Voltage level of cables included in the raceway.
      f. Contains:
         1) List of cables routed through the referenced raceway.
      g. Reference Drawing:
         1) A plan drawing on which the raceway is shown. A single raceway may pass through area shown on other drawings than the one referenced.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SCHEDULE

A. The raceway schedule consists of the following:

END OF SECTION

Engineer: NM
June 2024

Cable Tray/Raceway Schedule

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC01GEN2500	3/4	Raceway		CC-01GEN2500	ACC2101	GEN-2500		
RC01LSH2500	3/4	Raceway		CC-01LSH2500	ACC2101	01-LSH-2500		
RC01LSLL2500	3/4	Raceway		CC-01LSLL2500	ACC2101	01-LSLL-2500		
RC01MCC2150-C	3/4	Raceway		CC-01MCC2150C	ACC2101	MCC-2150		
RC01MCC2150-D	3/4	Raceway		CC-01MCC2150D	ACC2101	MCC-2150		
RC01MCC2150-E	3/4	Raceway		CC-01MCC2150E	ACC2101	MCC-2150		
RC01MCC2150-F	3/4	Raceway		CC-01MCC2150F	ACC2101	MCC-2150		
RC05LCP00015	1-1/2	Raceway		CC-05LCP00015	ACC2101	05-LCP-00015		
RC05LSH0007	1-1/2	Raceway		CV-05LSH00007	05-LCP-00015	05-LSH-00007		
				CV-05LSL00007				
				CV-05LSM00007				
RC20FIT00020	3/4	Raceway		CC-20FIT00020	35-PLC-9000	20-FIT-00020		
RC20LCP10010	3/4	Raceway		CC-20LCP10010	MCC-2155	20-LCP-10010		
RC20LCP20010	3/4	Raceway		CC-20LCP20010	MCC-2155	20-LCP-20010		
RC20LSH10011	3/4	Raceway		CC-20LSH10011	35-PLC-9000	20-LSH-10011		
RC20LSH20011	3/4	Raceway		CC-20LSH20011	35-PLC-9000	20-LSH-20011		
RC20P10010	3/4	Raceway		CC-20P10010	MCC-2155	20-P-10010		
RC20P20010	3/4	Raceway		CC-20P20010	MCC-2155	20-P-20010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC20PSH00012	3/4	Raceway		CC-20PSH00012	MCC-2155	20-PSH-00012		
RC20PSH00013	3/4	Raceway		CC-20PSH00013	MCC-2155	20-PSH-00013		
RC20PSH0001A	3/4	Raceway		CC-20PSH0001A	35-PLC-9000	20-PSH-0001A		
RC20SV10011	3/4	Raceway		CC-20SV10011	35-PLC-9000	20-SV-10011		
RC20SV10012	3/4	Raceway		CC-20SV10012	35-PLC-9000	20-SV-10012		
RC20SV20011	3/4	Raceway		CC-20SV20011	35-PLC-9000	20-SV-20011		
RC20SV20012	3/4	Raceway		CC-20SV20012	35-PLC-9000	20-SV-20012		
RC30CV10011	3/4	Raceway		CC-30CV10011	35-PLC-9000	30-CV-10011		
RC30CV20011	3/4	Raceway		CC-30CV20011	35-PLC-9000	30-CV-20011		
RC30LCP11010	3/4	Raceway		CC-30LCP11010	MCC-2155	30-LCP-11010		
RC30LCP11020	3/4	Raceway		CC-30LCP11020	MCC-2155	30-LCP-11020		
RC30LCP12010	3/4	Raceway		CC-30LCP12010	MCC-2155	30-LCP-12010		
RC30LCP12020	3/4	Raceway		CC-30LCP12020	MCC-2155	30-LCP-12020		
RC30LCP13010	3/4	Raceway		CC-30LCP13010	MCC-2155	30-LCP-13010		
RC30LCP13020	3/4	Raceway		CC-30LCP13020	MCC-2155	30-LCP-13020		
RC30LCP21010	3/4	Raceway		CC-30LCP21010	MCC-2155	30-LCP-21010		
RC30LCP21020	3/4	Raceway		CC-30LCP21020	MCC-2155	30-LCP-21020		
RC30LCP22010	3/4	Raceway		CC-30LCP22010	MCC-2155	30-LCP-22010		
RC30LCP22020	3/4	Raceway		CC-30LCP22020	MCC-2155	30-LCP-22020		
RC30LCP23010	3/4	Raceway		CC-30LCP23010	MCC-2155	30-LCP-23010		
RC30LCP23020	3/4	Raceway		CC-30LCP23020	MCC-2155	30-LCP-23020		
RC30P20010	3/4	Raceway		CC-30P20010	MCC-2155	30-P-20010		
RC35CV00019	1	Raceway		CC-35CV00019	35-PLC-9000	35-CV-00019		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC35LCP00050	1-1/2	Raceway		CC-35LCP00050	35-PLC-9000	35-LCP-00050		
RC35LCP00100	1-1/2	Raceway		CC-35LCP00100	35-PLC-9000	35-LCP-00100		
RC35LCS00010	1-1/4	Raceway		CC-35LCS00010	35-PLC-9000	35-LCS-00010		
RC35LCS00020	1-1/4	Raceway		CC-35LCS00020	MCC-2155	35-LCS-00020		
RC35LCS0010	1	Raceway		CC-35LCS0010	MCC-2155	35-LCS-0010		
RC35LSH00011	1-1/2	Raceway		CV-35LSH00011	35-LCP-00050	35-LSH00011		
				CV-35LSL00011				
				CV-35LSM00011				
RC35LSH00101	1-1/2	Raceway		CV-35LSH00101	35-LCP-00100	35-LSH00101		
				CV-35LSL00101				
				CV-35LSM00101				
RC35MCC2155A	1	Raceway		CC-35MCC2155A	35-PLC-9000	MCC-2155		
RC35MCC2155C	1	Raceway		CC-35MCC2155C	35-PLC-9000	MCC-2155		
RC35MCC2155D	1	Raceway		CC-35MCC2155D	35-PLC-9000	MCC-2155		
RC35MCC2155E	1-1/4	Raceway		CC-35MCC2155E	35-PLC-9000	MCC-2155		
RC35MCC2155G	1-1/4	Raceway		CC-35MCC2155G	35-PLC-9000	MCC-2155		
				CC-35MCC2155H				
RC35MCC2155H	1-1/4	Raceway		CC-35MCC2155I	35-PLC-9000	MCC-2155		
				CC-35MCC2155J				
RC35MCC2155I	1-1/4	Raceway		CC-35MCC2155K	35-PLC-9000	MCC-2155		
				CC-35MCC2155L				
RC35MCC2155J	1-1/4	Raceway		CC-35MCC2155M	35-PLC-9000	MCC-2155		
				CC-35MCC2155N				
RC35MCC2155K	1-1/4	Raceway		CC-35MCC2155O	35-PLC-9000	MCC-2155		
				CC-35MCC2155P				
RC35MCC2155L	1-1/4	Raceway		CC-35MCC2155Q	35-PLC-9000	MCC-2155		
				CC-35MCC2155R				
RC35PSH00022	3/4	Raceway		CC-35PSH00022	MCC-2155	35-PSH-00022		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC35PSL00012	3/4	Raceway		CC-35PSL00012	MCC-2155	35-PSL-00012		
RC40CV10011	1-1/4	Raceway		CC-40CV10011	35-LCP-9000	40-CV-10011		
RC40CV10012	3/4	Raceway		CC-40CV10012	35-PLC-9000	40-CV-10012		
RC40CV10021	1-1/4	Raceway		CC-40CV10021	35-LCP-9000	40-CV-10021		
RC40CV20011	1-1/4	Raceway		CC-40CV20011	35-LCP-9000	40-CV-20011		
RC40CV20012	3/4	Raceway		CC-40CV20012	35-PLC-9000	40-CV-20012		
RC40CV20021	1-1/4	Raceway		CC-40CV20021	35-LCP-9000	40-CV-20021		
RC40SV10001	3/4	Raceway		CC-40SV10001	35-PLC-9000	40-SV-10001		
RC40SV20001	3/4	Raceway		CC-40SV20001	35-PLC-9000	40-SV-20001		
RC40VCP10010	1-1/4	Raceway		CC-40VCP10010	35-PLC-9000	40-VCP-10010		
RC40VCP10020	1-1/4	Raceway		CC-40VCP10020	35-PLC-9000	40-VCP-10020		
RC40VCP20010	1-1/4	Raceway		CC-40VCP20010	35-PLC-9000	40-VCP-20010		
RC40VCP20020	1-1/4	Raceway		CC-40VCP20020	35-PLC-9000	40-VCP-20020		
RC50CS10031	1-1/4	Raceway		CV-50CS10031	35-CV-10031	35-CS-10031		
RC50CS20031	1	Raceway		CV-50CS20031	35-PLC-9002	50-CS-20031		
RC50CV00013	1	Raceway		CC-50CV00013	70-PLC-9000	50-CV-00013		
RC50CV00017	1-1/4	Raceway		CC-50CV00017	70-PLC-9000	50-CV-00017		
RC50CV00023	1	Raceway		CC-50CV00023	70-PLC-9000	50-CV-00023		
RC50CV10011	1-1/4	Raceway		CC-50CV10011	35-PLC-9001	50-CV-10011		
RC50CV10021	1	Raceway		CC-50CV10021	35-PLC-9001	50-CV-10021		
RC50CV10031	1-1/4	Raceway		CC-50CV10031	35-PLC-9000	35-CV-10031		
RC50CV10041	1	Raceway		CC-50CV10041	35-PLC-9001	50-CV-10041		
RC50CV10051	1	Raceway		CC-50CV10051	35-PLC-9001	50-CV-10051		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC50CV10061	1-1/4	Raceway		CC-50CV10061	35-PLC-9001	50-CV-10061		
RC50CV20011	1-1/4	Raceway		CC-50CV20011	35-PLC-9002	50-CV-20011		
RC50CV20021	1	Raceway		CC-50CV20021	35-PLC-9002	50-CV-20021		
RC50CV20031	1-1/4	Raceway		CC-50CV20031	35-PLC-9002	50-CV-20031		
RC50CV20041	1	Raceway		CC-50CV20041	35-PLC-9002	50-CV-20041		
RC50CV20051	1	Raceway		CC-50CV20051	35-PLC-9000	50-CV-20051		
RC50CV20061	1-1/4	Raceway		CC-50CV20061	35-PLC-9002	50-CV-20061		
RC50CV30011	1-1/4	Raceway		CC-50CV30011	35-PLC-9000	50-CV-30011		
RC50CV30021	1	Raceway		CC-50CV30021	35-PLC-9000	35-CV-30021		
RC50CV30031	1-1/4	Raceway		CC-50CV30031	35-PLC-9000	35-CV-30031		
RC50CV30041	1	Raceway		CC-50CV30041	35-PLC-9000	50-CV-30041		
RC50CV30051	1	Raceway		CC-50CV30051	35-PLC-9000	35-CV-30051		
RC50CV30061	1-1/4	Raceway		CC-50CV30061	35-PLC-9000	35-CV-30061		
RC50CV40011	1-1/4	Raceway		CC-50CV40011	35-PLC-9000	50-CV-40011		
RC50CV40021	1	Raceway		CC-50CV40021	35-PLC-9000	35-CV-40021		
RC50CV40031	1-1/4	Raceway		CC-50CV40031	35-PLC-9000	35-CV-40031		
RC50CV40041	1	Raceway		CC-50CV40041	35-PLC-9000	50-CV-40041		
RC50CV40051	1	Raceway		CC-50CV40051	35-PLC-9000	35-CV-40051		
RC50CV40061	1-1/4	Raceway		CC-50CV40061	35-PLC-9000	35-CV-40061		
RC50CV50011	1-1/4	Raceway		CC-50CV50011	35-PLC-9000	50-CV-50011		
RC50CV50021	1	Raceway		CC-50CV50021	35-PLC-9000	35-CV-50021		
RC50CV50031	1-1/4	Raceway		CC-50CV50031	35-PLC-9000	35-CV-50031		
RC50CV50041	1	Raceway		CC-50CV50041	35-PLC-9000	50-CV-50041		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC50CV50051	1	Raceway		CC-50CV50051	35-PLC-9000	35-CV-50051		
RC50CV50061	1-1/4	Raceway		CC-50CV50061	35-PLC-9000	35-CV-50061		
RC50CV60011	1-1/4	Raceway		CC-50CV60011	35-PLC-9000	50-CV-60011		
RC50CV60021	1	Raceway		CC-50CV60021	35-PLC-9000	35-CV-60021		
RC50CV60031	1-1/4	Raceway		CC-50CV60031	35-PLC-9000	35-CV-60031		
RC50CV60041	1	Raceway		CC-50CV60041	35-PLC-9000	50-CV-60041		
RC50CV60051	1	Raceway		CC-50CV60051	35-PLC-9000	35-CV-60051		
RC50CV60061	1-1/4	Raceway		CC-50CV60061	35-PLC-9000	35-CV-60061		
RC60CV00030	1	Raceway		CC-60CV00030	60-PLC-9000	60-CV-00030		
RC60CV00031	1	Raceway		CC-60CV00031	60-PLC-9000	60-CV-00031		
RC60CV00032	1	Raceway		CC-60CV00032	60-PLC-9000	60-CV-00032		
RC60LCS00013	3/4	Raceway		CC-60LCS00013	60-PP-CLARIFIER	60-LCS-00013		
RC60LSH00014	3/4	Raceway		CC-60LSH-00014	60-TJB-00010	60-LSH-00014		
				CC-60LSL-00014				
				CC-60LSM-00014				
RC60PPCLARIFIER	3/4	Raceway		CC-60PPCLARIFIER	60-PLC-9000	60-PP-CLARIFIER		
RC60TJB00010	3/4	Raceway		CC-60TJB00010	ACC-2300	60-TJB-00010		
RC70CV00099	1-1/4	Raceway		CC-70CV00099	70-PLC-9000	70-CV-00099		
RC70CV00100	1-1/4	Raceway		CC-70CV00100	70-PLC-9000	70-CV-00100		
RC70CV10010	1-1/4	Raceway		CC-70CV10010	70-PLC-9000	70-CV-10010		
RC70CV10020	1-1/4	Raceway		CC-70CV10020	70-PLC-9000	70-CV-10020		
RC70CV20010	1-1/4	Raceway		CC-70CV20010	70-PLC-9000	70-CV-20010		
RC70CV20020	1-1/4	Raceway		CC-70CV20020	70-PLC-9000	70-CV-20020		
RC70LCP00020	1-1/2	Raceway		CC-70LCP00020	70-PLC-9000	70-LCP-00020		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC70LCS00010	3/4	Raceway		CC-70LCS00010	MCC-2155	70-LCS-00010		
RC70LCS00060	3/4	Raceway		CC-70LCS00060	MCC-2155	70-LCS-00060		
RC70LCS00070	3/4	Raceway		CC-70LCS00070	MCC-2155	70-LCS-00070		
RC70LSH00017	3/4	Raceway		CV-70LSH00017	70-LCP-00020	70-LSH-00017		
				CV-70LSL00017				
				CV-70LSM00017				
RC70LSLL00060	3/4	Raceway		CC-70LSLL00060	70-PLC-9000	70-LSLL-00060		
RC70PSH00011	3/4	Raceway		CC-70PSH00011	MCC-2155	70-PSH-00011		
RC70VMP00010	2	Raceway		CC-70VMP00010E	MCC-2155	70-VMP-00010		
RC70VMP00020	2	Raceway		CC-70VMP00020E	MCC-2155	70-VMP-00020		
RC71CV00013	1	Raceway		CC-71CV00013	70-PLC-9000	71-CV-00013		
RC71CV00017	1-1/4	Raceway		CC-71CV00017	70-PLC-9000	71-CV-00017		
RC71CV00023	1	Raceway		CC-71CV00023	70-PLC-9000	71-CV-00023		
RC71CV00033	1	Raceway		CC-71CV00033	70-PLC-9000	71-CV-00033		
RC71LCS00010	1-1/4	Raceway		CC-71LCS00010	MCC-2155	RS71LCS00010		
RC71LCS00020	1-1/4	Raceway		CC-71LCS00020	MCC-2155	RS71LCS00020		
RC71LCS00030	1-1/4	Raceway		CC-71LCS00030	MCC-2155	RS71LCS00030		
RC71RSH00011	3/4	Raceway		CC-71TSH00011	MCC-2155	71-TSH-00011		
RC71RSH00021	3/4	Raceway		CC-71TSH00021	MCC-2155	71-TSH-00021		
RC71RSH00031	3/4	Raceway		CC-71TSH00031	MCC-2155	71-TSH-00031		
RC73CV00013	1-1/4	Raceway		CC-73CV00013	70-PLC-9000	73-CV-00013		
RC73CV00023	1-1/4	Raceway		CC-73CV00023	70-PLC-9000	73-CV-00023		
RC73LCS00010	3/4	Raceway		CC-73LCS00010	MCC-2155	73-LCS-00010		
RC73LCS00020	3/4	Raceway		CC-73LCS00020	MCC-2155	73-LCS-00020		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RC73TSH00011	3/4	Raceway		CC-73TSH00011	MCC-2155	73-TSH-00011		
RC73TSH00021	3/4	Raceway		CC-73TSH00021	MCC-2155	73-TSH-00021		
RC84FSL00014	1-1/2	Raceway		CC-84FSL00014	35-PLC-9000	84-FSL-00014		
RC84VCP10010	1	Raceway		CC-84VCP10010	35-PLC-9000	84-VCP-10010		
RC84VCP20010	1	Raceway		CC-84VCP20010	35-PLC-9000	84-VCP-20010		
RC89CV00012	1	Raceway		CS-89CV00012	ACC2101	89-CV-00012		
RC89CV00022	1	Raceway		CC-89CV00022	ACC2101	CV00022		
RC89LCS00010	3/4	Raceway		CC-89LCS00010	MCC-2150	89-LCS-00010		
RC89LCS00020	3/4	Raceway		CC-89LCS-00020	MCC-2150	89-LCS-00020		
RC89LCS00030	3/4	Raceway		CC-89LC00030	89-LCS-00030	MCC-2150		
RC89LCS00040	3/4	Raceway		CC-89LCS00040	MCC-2150	89-LCS-00040		
RC89LCS00050	3/4	Raceway		CC-89LCS00050	MCC-2150	89-LCS-00050		
RC89LSHH00010	3/4	Raceway		CC-89 LSHH00010	ACC2101	89-LSHH-00010		
RC89LSHH00020	3/4	Raceway		CC-89LSHH00020	ACC2101	89-LSHH-00020		
RC89LSLL00010	3/4	Raceway		CC-89 LSLL00010	ACC2101	89-LSLL-00010		
RC89LSLL00020	3/4	Raceway		CC-89LSLL00020	ACC2101	89-LSLL-00020		
RC89MCC2150-G	3/4	Raceway		CC-01MCC2150	ACC2101	MCC-2150		
RC89P00060	3/4	Raceway		CC-89P00060	ACC2101	89-P-00060		
RC89P00070	1	Raceway		CC-89P00070	ACC2101	89-P-00070		
RC89P00080	3/4	Raceway		CC-89P00080	ACC2101	89-P-00080		
RC89P00090	3/4	Raceway		CC-89P00090	ACC2101	89-P-00090		
RC89P00100	3/4	Raceway		CC-89P00100	ACC2101	89-P-00100		
RC89P00110	3/4	Raceway		CC-89P00110	ACC2101	89-P-00110		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP01ATS	3	Raceway		CP-01ATS	SWGR-2140	ATS		
RP01LIT2500	3/4	Raceway		CP-01 LIT2500	LP2175	01-LIT-2500		
RP01MCC2150B	3	Raceway		CP-70MCC2155B	SWGR-2140	MCC-2155		
RP01MCC2150C	3	Raceway		CP-70MCC2155C	SWGR-2140	MCC-2155		
RP01SWGR2140A	2	Raceway		CP-01SWGR2140A	SWGR-2140	CLARIFIER		
RP05LCP00015	3/4	Raceway		CP-05LCP00015	MCC-2150	05-LCP-00015		
RP05P00010	3/4	Raceway		CV-05P00010	05-LCP-00015	05-P-00010		
RP05P00020	3/4	Raceway		CV-05P00020	05-LCP-00015	05-P-00020		
RP20DS10010	1	Raceway		CP-20DS10010	MCC-2155	20-DS-10010		
RP20DS20010	1	Raceway		CP-20DS20010	MCC-2155	20-DS-20010		
RP20FIT00020	3/4	Raceway		CP-20FIT00020	2155-LP-01	20-FIT-00020		
RP20P10010	1	Raceway		CP-20P10010	20-DS-10010	20-P-10010		
RP20P20010	1	Raceway		CP-20P20010	20-DS-20010	20-P-20010		
RP30CV10011	3/4	Raceway		CP-30CV10011	30-DS-10011	30-CV-10011		
RP30CV20011	3/4	Raceway		CP-30CV20011	30-DS-10011	30-CV-20011		
RP30DS10011	3/4	Raceway		CP-30DS10011	2155-PP-03	30-DS-10011		
RP30DS11010	1	Raceway		CP-30DS11010	MCC-2155	30-DS-11010		
RP30DS11020	1	Raceway		CP-30DS11020	MCC-2155	30-DS-11020		
RP30DS12010	1	Raceway		CP-30DS12010	MCC-2155	30-DS-12010		
RP30DS12020	1	Raceway		CP-30DS12020	MCC-2155	30-DS-12020		
RP30DS13010	1	Raceway		CP-30DS13010	MCC-2155	30-DS-13010		
RP30DS13020	1	Raceway		CP-30DS13020	MCC-2155	30-DS-13020		
RP30DS20010A	1	Raceway		CP-30DS20010	MCC-2155	30-DS-20010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP30DS20011	3/4	Raceway		CP-30DS20011	2155-PP-03	30-DS-20011		
RP30DS21010	1	Raceway		CP-30DS21010	MCC-2155	30-DS-21010		
RP30DS21020	1	Raceway		CP-30DS21020	MCC-2155	30-DS-21020		
RP30DS22010	1	Raceway		CP-30DS22010	MCC-2155	30-DS-22010		
RP30DS22020	1	Raceway		CP-30DS22020	MCC-2155	30-DS-22020		
RP30DS23010	1	Raceway		CP-30DS23010	MCC-2155	30-DS-23010		
RP30DS23020	1	Raceway		CP-30DS23020	MCC-2155	30-DS-23020		
RP30FIT10011	3/4	Raceway		CP-30FIT10011	2155-LP-01	30-FIT-10011		
RP30FIT20011	3/4	Raceway		CP-30FIT20011	2155-LP-01	30-FIT-20011		
RP30MX11010	1	Raceway		CP-30MX11010	30-DS-11010	30-MX-11010		
RP30MX11020	1	Raceway		CP-30MX11020	30-DS-11020	30-MX-11020		
RP30MX12010	1	Raceway		CP-30MX12010	30-DS-12010	30-MX-12010		
RP30MX12020	1	Raceway		CP-30MX12020	30-DS-12020	30-MX-12020		
RP30MX13010	1	Raceway		CP-30MX13010	30-DS-13010	30-MX-13010		
RP30MX13020	1	Raceway		CP-30MX13020	30-DS-13020	30-MX-13020		
RP30MX21010	1	Raceway		CP-30MX21010	30-DS-21010	30-MX-21010		
RP30MX21020	1	Raceway		CP-30MX21020	30-DS-21020	30-MX-21020		
RP30MX22010	1	Raceway		CP-30MX22010	30-DS-22010	30-MX-22010		
RP30MX22020	1	Raceway		CP-30MX22020	30-DS-22020	30-MX-22020		
RP30MX23010	1	Raceway		CP-30MX23010	30-DS-23010	30-MX-23010		
RP30MX23020	1	Raceway		CP-30MX23020	30-DS-23020	30-MX-23020		
RP30P20010	1	Raceway		CP-30P20010	30-DS-20010	30-P-20010		
RP35AIT00023	3/4	Raceway		CP-35AIT00023	2155-LP-01	35-AIT-00023		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP35CU00010	3/4	Raceway		CP-35CU-00010	2155-LP-02	35-CU-00010		
RP35CU00020	3/4	Raceway		CP-35CU-00020	2155-LP-03	35-CU-00020		
RP35CU00030	3/4	Raceway		CP-35CU-00030	2155-LP-02	35-CU-00030		
RP35CU00040	3/4	Raceway		CP-35CU-00040	2155-LP-03	35-CU-00040		
RP35CV00019	3/4	Raceway		CP-35CV00019	2155-PP-05	35-CV-00019		
RP35DS00010	3/4	Raceway		CP-35DS00010	MCC-2155	35-DS-00010		
RP35DS00010A	3/4	Raceway		CP-35DS00010A	MCC-2155	35-DS-00010A		
RP35DS00010B	1	Raceway		CP-35DS0001B	MCC-2155	35-DS-00010B		
RP35DS00020	3/4	Raceway		CP-35DS00020	MCC-2155	35-DS-00020		
RP35DS00020A	3/4	Raceway		CP-35DS00020A	MCC-2155	35-DS-00020A		
RP35DS00030	1	Raceway		CP-35DS00030	MCC-2155	35-DS-00030		
RP35DS00040	1	Raceway		CP-35DS00040	MCC-2155	35-DS-00040		
RP35EF00010	3/4	Raceway		CP-35EF00010	35-DS-00010A	35-EF-00010		
RP35EF00020	3/4	Raceway		CP-35EF00020	35-DS-00020	35-EF-00020		
RP35F00010	3/4	Raceway		CP-35F-00010	2155-LP-02	35-F-00010		
RP35F00020	3/4	Raceway		CP-35F-00020	2155-LP-03	35-F-00020		
RP35F00030	3/4	Raceway		CP-35F-00030	2155-LP-02	35-F-00030		
RP35F00040	3/4	Raceway		CP-35F-00040	2155-LP-03	35-F-00040		
RP35FIT00012	3/4	Raceway		CP-35FIT00011	2155-LP-01	35-FIT-00012		
				CP-35FIT00012				
RP35LCP00050	3/4	Raceway		CP-35DS00050	MCC-2155	35-LCP-00050		
RP35LCP00100	3/4	Raceway		CP-35LCP00100	MCC-2155	35-LCP-00100		
RP35MAU00010	1	Raceway		CP-35MAU00010	35-DS-00010B	35-MAU-00010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP35P00010	3/4	Raceway		CP-35P00010	35-DS-00010	35-P-00010		
RP35P00020	1-1/4	Raceway		CP-35P00020	35-DS-00020	35-P-00020		
RP35P00030	1	Raceway		CP-35P00030	35-DS-00030	35-P-00030		
RP35P00040	1	Raceway		CP-35P00040	35-DS-00040	35-P-00040		
RP35P00050	3/4	Raceway		CV-35P00050	35-LCP-00050	35-P-00050		
RP35P00060	3/4	Raceway		CV-35P00060	35-LCP-00050	35-P-00060		
RP35P00090	3/4	Raceway		CP-35P00090	2155-LP-03	35-P00090		
RP35P00100	3/4	Raceway		CV-35P00100	35-LCP-00100	35-P-00100		
RP35P00110	3/4	Raceway		CV-35P00110	35-LCP-00100	35-P-00110		
RP35SS00010	3/4	Raceway		CP-35SS-00010	35-CU-00010	35-SS-00010		
RP35SS00020	3/4	Raceway		CP-35SS-00020	35-CU-00020	35-SS-00020		
RP35SS00030	3/4	Raceway		CP-35SS-00030	35-CU-00030	35-SS-00030		
RP35SS00040	3/4	Raceway		CP-35SS-00040	35-CU-00040	35-SS-00040		
RP35WH00001	3/4	Raceway		CP-35WH00001	2155-LP-02	35-WH-00001		
RP40AIT10004	3/4	Raceway		CP-40AIT10004	2155-LP-01	40-AIT-10004		
RP40AIT20004	3/4	Raceway		CP-40AIT20004	2155-LP-01	40-AIT-20004		
RP40COL10010	3/4	Raceway		CP-40COL10010	40-VCP-10010	40-COL-10010		
RP40COL10020	3/4	Raceway		CP-40COL10020	40-VCP-10020	40-COL-10020		
RP40COL20010	3/4	Raceway		CP-40COL20010	40-CVCP-20010	40-COL-20010		
RP40COL20020	3/4	Raceway		CP-40COL20020	40-VCP-20020	40-COL-20020		
RP40CV10011	3/4	Raceway		CP-40CV10011	RP40DS10011	40-DS-10011		
RP40CV10012	3/4	Raceway		CP-40CV10012	40-DS-10012	40-CV-10012		
RP40CV10021	3/4	Raceway		CP-40CV10021	40-DS-10021	40-CV-10021		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP40CV20011	3/4	Raceway		CP-40CV20011	40-DS-20011	40-CV-20011		
RP40CV20012	3/4	Raceway		CP-40CV20012	40-DS-20012	40-CV-20012		
RP40CV20021	3/4	Raceway		CP-40CV20021	40-DS-20021	40-CV-20021		
RP40DS10011	3/4	Raceway		CP-40CV10011	2155-PP-01	RP40CV10011		
RP40DS10012	3/4	Raceway		CP-40DS10012	2155-PP-01	40-DS-10012		
RP40DS10021	3/4	Raceway		CP-40DS10021	2155-PP-01	40-DS-10021		
RP40DS20011	3/4	Raceway		CP-40DS20011	2155-PP-02	40-DS-20011		
RP40DS20012	3/4	Raceway		CP-40DS20012	2155-PP-02	40-DS-20012		
RP40DS20021	3/4	Raceway		CP-40DS20021	2155-PP-02	40-DS-20021		
RP40VCP10010	3/4	Raceway		CP-40VCP10010	2155-LP-03	40-VCP-10010		
RP40VCP10020	3/4	Raceway		CP-40VCP10020	2155-LP-03	40-VCP-10020		
RP40VCP20010	3/4	Raceway		CP-40VCP20010	2155-LP-03	40-CVCP-20010		
RP40VCP20020	3/4	Raceway		CP-40VCP20020	2155-LP-03	40-VCP-20020		
RP50AIT10131	3/4	Raceway		CP-50AIT10131	2155-LP-01	50-AIT-10131		
RP50AIT20131	3/4	Raceway		CP-50AIT20131	2155-LP-01	50-AIT-20131		
RP50CV00013	3/4	Raceway		CP-50CV00013	50-DS-00013	50-CV-00013		
RP50CV00017	3/4	Raceway		CP-50CV00017	50-DS-00017	50-CV-00017		
RP50CV00023	3/4	Raceway		CP-50CV00023	50-DS-00023	50-CV-00023		
RP50CV10011	3/4	Raceway		CP-50CV10011	50-DS-10011	50-CV-10011		
RP50CV10021	3/4	Raceway		CP-50CV10021	50-DS-10021	50-CV-10021		
RP50CV10031	3/4	Raceway		CP-50CV10031	35-DS-10031	35-CV-10031		
RP50CV10041	3/4	Raceway		CP-50CV10041	50-DS-10041	50-CV-10041		
RP50CV10051	3/4	Raceway		CP-50CV10051	50-DS-10051	50-CV-10051		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP50CV10061	3/4	Raceway		CP-50CV10061	35-DS-10061	50-CV-10061		
RP50CV20011	3/4	Raceway		CP-50CV20011	50-DS-20011	50-CV-20011		
RP50CV20021	3/4	Raceway		CP-50CV20021	50-DS-20021	50-CV-20021		
RP50CV20031	3/4	Raceway		CP-50CV20031	50-DS-20031	50-CV-20031		
RP50CV20041	3/4	Raceway		CP-50CV20041	50-DS-20041	50-CV-20041		
RP50CV20051	3/4	Raceway		CP-50CV20051	50-DS-20051	50-CV-20051		
RP50CV20061	3/4	Raceway		CP-50CV20061	50-DS-20061	50-CV-20061		
RP50CV30011	3/4	Raceway		CP-50CV30011	2155-PP-03	50-CV-30011		
RP50CV30021	3/4	Raceway		CP-50CV30021	2155-PP-03	35-CV-30021		
RP50CV30031	3/4	Raceway		CP-50CV30031	2155-PP-03	35-CV-30031		
RP50CV30041	3/4	Raceway		CP-50CV30041	2155-PP-03	50-CV-30041		
RP50CV30051	3/4	Raceway		CP-50CV30051	2155-PP-03	35-CV-30051		
RP50CV30061	3/4	Raceway		CP-50CV30061	2155-PP-03	35-CV-30061		
RP50CV40011	3/4	Raceway		CP-50CV40011	2155-PP-04	50-CV-40011		
RP50CV40021	3/4	Raceway		CP-50CV40021	2155-PP-04	35-CV-40021		
RP50CV40031	3/4	Raceway		CP-50CV40031	2155-PP-04	35-CV-40031		
RP50CV40041	3/4	Raceway		CP-50CV40041	2155-PP-04	50-CV-40041		
RP50CV40051	3/4	Raceway		CP-50CV40051	2155-PP-04	35-CV-40051		
RP50CV40061	3/4	Raceway		CP-50CV40061	2155-PP-04	35-CV-40061		
RP50CV50011	3/4	Raceway		CP-50CV50011	2155-PP-05	50-CV-50011		
RP50CV50021	3/4	Raceway		CP-50CV50021	2155-PP-05	35-CV-50021		
RP50CV50031	3/4	Raceway		CP-50CV50031	2155-PP-05	35-CV-50031		
RP50CV50041	3/4	Raceway		CP-50CV50041	2155-PP-05	50-CV-50041		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP50CV50051	3/4	Raceway		CP-50CV50051	2155-PP-05	35-CV-50051		
RP50CV50061	3/4	Raceway		CP-50CV50061	2155-PP-05	35-CV-50061		
RP50CV60011	3/4	Raceway		CP-50CV60011	2155-PP-06	50-CV-60011		
RP50CV60021	3/4	Raceway		CP-50CV60021	2155-PP-06	35-CV-60021		
RP50CV60031	3/4	Raceway		CP-50CV60031	2155-PP-06	35-CV-60031		
RP50CV60041	3/4	Raceway		CP-50CV60041	2155-PP-06	50-CV-60041		
RP50CV60051	3/4	Raceway		CP-50CV60051	2155-PP-06	35-CV-60051		
RP50CV60061	3/4	Raceway		CP-50CV60061	2155-PP-06	35-CV-60061		
RP50DS00013	3/4	Raceway		CP-50DS00013	2155-PP-06	50-DS-00013		
RP50DS00017	3/4	Raceway		CP-50DS00017	2155-PP-06	50-DS-00017		
RP50DS00023	3/4	Raceway		CP-50DS00023	2155-PP-06	50-DS-00023		
RP50DS10011	3/4	Raceway		CP-50DS10011	2155-PP-01	50-DS-10011		
RP50DS10021	3/4	Raceway		CP-50DS10021	2155-PP-01	50-DS-10021		
RP50DS10031	3/4	Raceway		CP-50DS10031	2155-PP-01	35-DS-10031		
RP50DS10041	3/4	Raceway		CP-50DS10041	2155-PP-01	50-DS-10041		
RP50DS10051	3/4	Raceway		CP-50DS10051	2155-PP-01	50-DS-10051		
RP50DS10061	3/4	Raceway		CP-50DS10061	2155-PP-01	50-DS-10061		
RP50DS20011	3/4	Raceway		CP-50DS20011	2155-PP-02	50-DS-20011		
RP50DS20021	3/4	Raceway		CP-50DS20021	2155-PP-02	50-DS-20021		
RP50DS20031	3/4	Raceway		CP-50DS20031	2155-PP-02	50-DS-20031		
RP50DS20041	3/4	Raceway		CP-50DS20041	2155-PP-02	50-DS-20041		
RP50DS20051	3/4	Raceway		CP-50DS20051	2155-PP-02	50-DS-20051		
RP50DS20061	3/4	Raceway		CP-50DS20061	2155-PP-02	50-DS-20061		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP50FIT10010	3/4	Raceway		CP-50FIT10010	2155-LP-01	50-FIT-10010		
RP50FIT20010	3/4	Raceway		CP-50FIT20010	2155-LP-01	50-FIT-20010		
RP50LIT20111	3/4	Raceway		CP-50LIT20111	2155-LP-02	50-LIT-20111		
RP50LIT30111	3/4	Raceway		CP-50LIT30111	2155-LP-03	50-LIT-30111		
RP50LIT40111	3/4	Raceway		CP-50LIT40111	2155-LP-04	50-LIT-40111		
RP50LIT50111	3/4	Raceway		CP-50LIT50111	2155-LP-05	50-LIT-50111		
RP50LIT60111	3/4	Raceway		CP-50LIT60111	2155-LP-06	50-LIT-60111		
RP50LT00016	3/4	Raceway		CP-50LT00016	2155-LP-01	50-LT-00016		
RP50LT10111	3/4	Raceway		CP-50LT10111	2155-LP-01	50-LT-10111		
RP60CL00013	3/4	Raceway		CP-60CL00013	60-DS-00013	60-CL-00013		
RP60CV00030	3/4	Raceway		CP-60CV00030	60-PP-CLARIFIER	60-CV-00030		
RP60CV00031	3/4	Raceway		CP-60CV00031	60-PP-CLARIFIER	60-CV-00031		
RP60CV00032	3/4	Raceway		CP-60CV00032	60-PP-CLARIFIER	60-CV-00032		
RP60DS00013	3/4	Raceway		CP-60DS00013	60-PP-CLARIFIER	60-DS-00013		
RP60LIT00012	3/4	Raceway		CP-60LIT00012	60-LP-CLARIFIER	60-LIT-00012		
RP60P00010	1	Raceway		CV-60P00010	60-TJB-00020	60-P-00010		
RP60P00020	1	Raceway		CV-60P00020	60-TJB-00020	60-P-00020		
RP60TJB00010	3	Raceway		CP-60TJB00010A	60-PP-CLARIFIER	60-TJB-00010		
				CP-60TJB00010B				
RP70B00010	2-1/2	Raceway		CP-70B00010	70-DS-00010E	70-B-00010		
RP70B00020	2-1/2	Raceway		CP-70B00020	70-DS-00020E	70-B-00020		
RP70CV10010	3/4	Raceway		CP-70CV10010	70-DS-10010	70-CV-10010		
RP70DS00010A	3/4	Raceway		CP-70DS00010A	MCC-2155	70-DS-00010A		
RP70DS00010B	3/4	Raceway		CP-70DS00010B	MCC-2160	70-DS-00010B		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP70DS00010C	3/4	Raceway		CP-70DS00010C	MCC-2160	70-DS-00010C		
RP70DS00010D	3/4	Raceway		CP-70DS00010D	MCC-2160	70-DS-00010D		
RP70DS00010E	3	Raceway		CP-70DS00010E	MCC-2155	70-DS-00010E		
RP70DS00020B	3/4	Raceway		CP-70DS00020B	MCC-2160	70-DS-00020B		
RP70DS00020E	3	Raceway		CP-70DS00020E	MCC-2155	70-DS-00020E		
RP70DS00060	3/4	Raceway		CP-70DS00060	MCC-2155	70-DS-00060		
RP70DS00070	3/4	Raceway		CP-70DS00070	MCC-2155	70-DS-00070		
RP70DS00099	3/4	Raceway		CP-70DS00099	2155-PP-05	70-DS-00099		
RP70DS00100	3/4	Raceway		CP-70DS00100	2155-PP-05	70-DS-00100		
RP70DS10010	3/4	Raceway		CP-70DS10010	2155-PP-03	70-DS-10010		
RP70DS10010A	3/4	Raceway		CP-70DS10010A	MCC-2160	70-DS-10010A		
RP70DS10020	3/4	Raceway		CP-70DS10020	2155-PP-03	70-DS-10020		
RP70DS10020A	3/4	Raceway		CP-70DS10020A	MCC-2160	70-DS-10020A		
RP70DS10030	3/4	Raceway		CP-70DS10030	MCC-2160	70-DS-10030		
RP70DS20010	3/4	Raceway		CP-70DS20010	2155-PP-04	70-DS-20010		
RP70DS20010A	3/4	Raceway		CP-70DS20010A	MCC-2160	70-DS-20010A		
RP70DS20020	3/4	Raceway		CP-70DS20020	2155-PP-04	70-DS-20020		
RP70DS20020A	3/4	Raceway		CP-70DS20020A	MCC-2160	70-DS-20020A		
RP70DS20030	3/4	Raceway		CP-70DS20030	MCC-2160	70-DS-20030		
RP70DSCRN	1	Raceway		CP-70DSCRN	MCC-2155	70-DS-CRN		
RP70EF00010	3/4	Raceway		CP-70EF00010	70-DS-00010D	70-EF-00010		
RP70EF00020	3/4	Raceway		CP-70EF00020	70-DS-00020B	70-EF-00020		
RP70FIT00010	3/4	Raceway		CP-70FIT00010	2155-LP-01	70-FIT-00010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP70FIT00020	3/4	Raceway		CP-70FIT00020	2155-LP-02	70-FIT-00020		
RP70GT00010	3/4	Raceway		CP-70P00010	70-DS-00010B	70-GT-00010		
RP70GT10010	3/4	Raceway		CP-70GT10010	70-DS-10010A	70-GT-10010		
RP70GT10020	3/4	Raceway		CP-70GT10020	70-DS-10020A	70-GT-10020		
RP70GT10030	3/4	Raceway		CP-70GT10030	70-DS-10030	70-GT-10030		
RP70GT20010	3/4	Raceway		CP-70GT20010	70-DS-20010A	70-GT-20010		
RP70GT20020	3/4	Raceway		CP-70GT20020	70-DS-20020A	70-GT-20020		
RP70GT20030	3/4	Raceway		CP-70GT20030	70-DS-20030	70-GT-20030		
RP70LCP00020	3/4	Raceway		CP-70LCP00020	MCC-2160	70-LCP-00020		
RP70LCS00040	3/4	Raceway		CP-70LCS00040	2155-LP-03	70-LCS-00040		
RP70LCS00050	3/4	Raceway		CP-70LCS00050	2155-LP-03	70-LCS-00050		
RP70LIT10010	3/4	Raceway		CP-70LIT10010	2155-LP-03	70-LIT-10010		
RP70LIT20010	3/4	Raceway		CP-70LIT20010	2155-LP-03	70-LIT-20010		
RP70MAU00010	3/4	Raceway		CP-70MAU00010	70-DS-00010C	70-MAU-00010		
RP70MCC2150A	3	Raceway		CP-70MCC2155A	SWGR-2140	MCC-2155		
RP70MCC2150D	3	Raceway		CP-70MCC2155D	SWGR-2140	MCC-2155		
RP70MCC2150E	3	Raceway		CP-70MCC2155E	SWGR-2140	MCC-2155		
RP70MCC2150F	3	Raceway		CP-70MCC2155F	SWGR-2140	MCC-2155		
RP70P00010	3/4	Raceway		CP-70P00010	70-DS-00010A	70-P-00010		
RP70P00020	1	Raceway		CV-70P00020	70-DS-00020A	70-P-00020		
RP70P00030	1	Raceway		CV-70P00030	70-DS-00030	70-P-00030		
RP70P00040	3/4	Raceway		CP-70P00040	70-LCS-00040	70-P-00040		
RP70P00050	3/4	Raceway		CP-70P00050	70-LCS-00050	70-P-00050		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP70P00060	3/4	Raceway		CP-70P00060	70-DS-00060	70-P-00060		
RP70P00070	3/4	Raceway		CP-70P00070	70-DS-00070	70-P-00070		
RP70SWGR2140A	3-1/2	Raceway		CP-70SWGR2140A	UTILITY TRANSFORMER	SWGR-2140		
RP70SWGR2140B	3-1/2	Raceway		CP-70SWGR2140B	UTILITY TRANSFORMER	SWGR-2140		
RP70SWGR2140C	3-1/2	Raceway		CP-70SWGR2140C	UTILITY TRANSFORMER	SWGR-2140		
RP70SWGR2140D	3-1/2	Raceway		CP-70SWGR2140D	UTILITY TRANSFORMER	SWGR-2140		
RP71CV00013	3/4	Raceway		CP-71CV00013	2155-PP-01	71-CV-00013		
RP71CV00017	3/4	Raceway		CP-71CV00017	2155-PP-01	71-CV-00017		
RP71CV00023	3/4	Raceway		CP-71CV00023	2155-PP-01	71-CV-00023		
RP71CV00033	3/4	Raceway		CP-71CV00033	2155-PP-01	71-CV-00033		
RP71DS00010	3	Raceway		CP-71	71-VFD-00010	71-DS-00010		
RP71DS00020	3	Raceway		CP-71DS00020	71-VFD-00020	71-DS-00020		
RP71DS00030	2-1/2	Raceway		CP-71DS00030	71-VFD-00030	71-DS-00030		
RP71P00010	3	Raceway		CP-71P00010	71-DS-00010	71-P-00010		
RP71P00020	3	Raceway		CP-71P00020	71-DS-00020	71-P-00020		
RP71P00030	2	Raceway		CP-71P00030	71-DS-00030	71-P-00030		
RP71VFD00010	2-1/2	Raceway		CP-71VFD00010	MCC-2155	71-VFD-00010		
RP71VFD00020	3	Raceway		CP-71VFD00020	MCC-2160	71-VFD-00020		
RP71VFD00030	2-1/2	Raceway		CP-71VFD00030	MCC-2155	71-VFD-00030		
RP73CV00013	3/4	Raceway		CP-73CV00013	73-DS-00013	73-CV-00013		
RP73CV00023	3/4	Raceway		CP-73CV00023	73-DS-00023	73-CV-00023		
RP73DS00010	1-1/4	Raceway		CP-73DS00010	MCC-2155	73-DS-00010		
RP73DS00013	3/4	Raceway		CP-73DS00013	2155-PP-02	73-DS-00013		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP73DS00020	1-1/4	Raceway		CP-73DS00020	MCC-2155	73-DS-00020		
RP73DS00023	3/4	Raceway		CP-73DS00023	2155-PP-02	73-DS-00023		
RP73P00010	1-1/4	Raceway		CP-73P00010	73-DS-00010	73-P-00010		
RP73P00020	1-1/4	Raceway		CP-73P00020	73-DS-00020	73-P-00020		
RP84DS00010	3/4	Raceway		CP-84DS00010	MCC-2155	84-DS-00010		
RP84DS00020	3/4	Raceway		CP-84DS00020	MCC-2155	84-DS-00020		
RP84DS00030	3/4	Raceway		CP-84DS00030	MCC-2155	84-DS-00030		
RP84DS00040	3/4	Raceway		CP-84DS00040	MCC-2155	84-DS-00040		
RP84DS00050	3/4	Raceway		CP-84DS00050	MCC-2155	84-DS-00050		
RP84DS00060	3/4	Raceway		CP-84DS00060	MCC-2155	84-DS-00060		
RP84LIT00021	3/4	Raceway		CP-84LIT00021	2155-LP-02	84-LIT-00021		
RP84P00010	3/4	Raceway		CP-84P00010	84-DS-00010	84-P-00010		
RP84P00020	3/4	Raceway		CP-84P00020	84-DS-00020	84-P-00020		
RP84P00030	3/4	Raceway		CP-84P00030	84-DS-00030	84-P-00030		
RP84P00040	3/4	Raceway		CP-84P00040	84-DS-00040	84-P-00040		
RP84P00050	3/4	Raceway		CP-84P00050	84-DS-00050	84-P-00050		
RP84P00060	3/4	Raceway		CP-84P00060	84-DS-00060	84-P-00060		
RP84VCP10010	3/4	Raceway		CP-84VCP10010	2155-PP-06	84-VCP-10010		
RP84VCP20010	3/4	Raceway		CP-84VCP20010	2155-PP-06	84-VCP-20010		
RP87CU	3/4	Raceway		CP-87CU	87-LP-2271	87-CU		
RP87DS00010	3/4	Raceway		CP-87DS00010	MCC-2155	87-DS-00010		
RP87EF	3/4	Raceway		CP-87EF	87-LP-2271	87-EF		
RP87MAU	3/4	Raceway		CP-87MAU	87-LP-2271	87-MAU		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP87MAU00010	3/4	Raceway		CP-87MAU00010	87-DS-00010	87-MAU-00010		
RP89CV00012	3/4	Raceway		CP-89CV00012	89-DS-00012	89-CV-00012		
RP89CV00022	3/4	Raceway		CP-89CV00022	89-DS-00022	89-CV-00022		
RP89DS00010	3/4	Raceway		CP-89DS00010	MCC-2150	89-DS-00010		
RP89DS00012	3/4	Raceway		CP-89DS00012	LP2175	89-DS-00012		
RP89DS00020	3/4	Raceway		CP-89DS00020	MCC-2150	89-DS-00020		
RP89DS00022	3/4	Raceway		CP-89DS00022	LP2175	89-DS-00022		
RP89DS00030	3/4	Raceway		CP-89DS00030	MCC-2150	89-DS-00030		
RP89DS00040	3/4	Raceway		CP-89DS00040	MCC-2150	89-DS-00040		
RP89DS00050	3/4	Raceway		CP-89DS00050	MCC-2150	89-DS-00050		
RP89DS00060	3/4	Raceway		CP-89DS00060	LP2175	89-DS-00060		
RP89DS00070	3/4	Raceway		CP-89DS00070	LP2175	89-DS-00070		
RP89DS00080	3/4	Raceway		CP-89DS00080	LP2175	89-DS-00080		
RP89DS00090	3/4	Raceway		CP-89DS00090	LP2175	89-DS-00090		
RP89DS00100	3/4	Raceway		CP-89DS00100	LP2175	89-DS-00100		
RP89DS00110	3/4	Raceway		CP-89DS00110	LP2175	89-DS-00110		
RP89FIT00065	3/4	Raceway		CP-89FIT00065	LP2175	89-FIT-00065		
RP89FIT00082	3/4	Raceway		CP-89FIT00082	LP2175	89-FIT-00082		
RP89FIT00095	3/4	Raceway		CP-89FIT00095	LP2175	89-FIT-00095		
RP89FIT00112	3/4	Raceway		CP-89FIT00112	LP2175	89-FIT-00112		
RP89LIT00010	3/4	Raceway		CP-89LIT00010	LP2175	89-LIT-00010		
RP89LIT00020	3/4	Raceway		CP-89LIT00020	LP2175	89-LIT-00020		
RP89P00010	3/4	Raceway		CP-89P00010	89-DS-00010	89-P-00010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RP89P00020	3/4	Raceway		CP-89P00020	89-DS-00020	89-P-00020		
RP89P00030	3/4	Raceway		CP-89P00030	89-DS-00030	89-P-00030		
RP89P00040	3/4	Raceway		CP-89P00040	89-DS-00040	89-P-00040		
RP89P00050	3/4	Raceway		CP-89P00050	89-DS-00050	89-P-00050		
RP89P00060	3/4	Raceway		CP-89P00060	89-DS-00060	89-P-00060		
RP89P00070	3/4	Raceway		CP-89P00070	89-DS-00070	89-P-00070		
RP89P00080	3/4	Raceway		CP-89P00080	89-DS-00080	89-P-00080		
RP89P00090	3/4	Raceway		CP-89P00090	89-DS-000090	89-P-00090		
RP89P00100	3/4	Raceway		CP-89P00100	89-DS-00100	89-P-00100		
RP89P00110	3/4	Raceway		CP-89P00110	89-DS-00110	89-P-00110		
RS01FOPP01A	2	Raceway	DB-01	CS-01FOPP01A	ACC 2100	MH-01		
				CS-01FOPP01B				
RS01FOPP01B	2	Raceway	DB-02	CS-01FOPP01A	MH-01	MH-02		
				CS-01FOPP01B				
RS01FOPP01C	2	Raceway	DB-05	CS-01FOPP01A	MH-02	TS351014		
				CS-01FOPP01B				
RS01GEN2500	3/4	Raceway		CS-01GEN2500	ACC2101	GEN-2500		
RS01LIT2500	3/4	Raceway		CS-01LIT2500	ACC2101	01-LIT-2500		
RS20FIT00020	3/4	Raceway		CS-20FIT00020	35-PLC-9000	20-FIT-00020		
RS30CV10011	3/4	Raceway		CS-30CV10011	35-PLC-9000	30-CV-10011		
RS30CV20011	3/4	Raceway		CS-30CV20011	35-PLC-9000	30-CV-20011		
RS30FE10011	3/4	Raceway		CS-30FE10011	30-FIT-10011	30-FE-10011		
RS30FE20011	3/4	Raceway		CS-30FE20011	30-FIT-10011	30-FE-20011		
RS30FIT10011	3/4	Raceway		CS-30FIT10011	35-PLC-9000	30-FIT-10011		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS30FIT20011	3/4	Raceway		CS-30FIT20011	35-PLC-9000	30-FIT-20011		
RS35AE00023	3/4	Raceway		CV-35AE00023	35-AIT-00023	35-AE-00023		
RS35AIT00023	3/4	Raceway		CS-35AIT00023	35-PLC-9000	35-AIT-00023		
RS35CV00019	3/4	Raceway		CS-35CV00019	35-PLC-9000	35-CV-00019		
RS35DP00013	1-1/4	Raceway		CS-35DP00013A	70-PLC-9000	35-DP-00013		
				CS-35DP00013C				
RS35DP00013A	3/4	Raceway		CS-35DP00013B	70-PLC-9000	35-DP-00013		
RS35FE00012	1	Raceway		CS-35FE00011	35-FIT-00012	35-FE-00012		
				CS-35FE00012				
RS35FIT00012	1	Raceway		CS-35FIT00011	35-PLC-9000	35-FIT-00012		
				CS-35FIT00012				
RS35FIT00018	3/4	Raceway		CS-35FIT00018	35-PLC-9000	35-FIT-00018		
RS35FIT10011	3/4	Raceway		CS-35FIT10011	35-PLC-9000	35-FIT-10011		
RS35FIT20011	3/4	Raceway		CS-35FIT20011	35-PLC-9000	35-FIT-20011		
RS35MCC2155A	3/4	Raceway		CS-35MCC2155A	35-PLC-9000	MCC-2155		
RS35MCC2155B	3/4	Raceway		CS-35MCC2155B	35-PLC-9000	MCC-2155		
RS35PLC9000	3/4	Raceway		CS-35PLC9000	FOPP-01	TS352001		
RS35PLC9000A	3/4	Raceway		CS-35PLC9000A	IT NETWORK ENCLOSURE	35-PLC-9000		
RS35PLC9001	1	Raceway		CS-35PLC9001	35-PLC-9000	35-PLC-9001		
RS35PLC9001A	3/4	Raceway		CS-35PLC9001A	IT NETWORK ENCLOSURE	35-PLC-9001		
RS35PLC9002	1	Raceway		CS-35PLC9002	35-PLC-9000	35-PLC-9002		
RS35PLC9002A	3/4	Raceway		CS-35PLC9002A	IT NETWORK ENCLOSURE	35-PLC-9002		
RS35PLC9003	1	Raceway		CS-35PLC9003	35-PLC-9000	35-PLC-9003		
RS35PLC9003A	3/4	Raceway		CS-35PLC9003A	IT NETWORK ENCLOSURE	35-PLC-9003		
RS35PLC9004	1	Raceway		CS-35PLC9004	35-PLC-9000	35-PLC-9004		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS35PLC9004A	3/4	Raceway		CS-35PLC9004A	IT NETWORK ENCLOSURE	35-PLC-9004		
RS35PLC9005	1	Raceway		CS-35PLC9005	35-PLC-9000	35-PLC-9005		
RS35PLC9005A	3/4	Raceway		CS-35PLC9005A	IT NETWORK ENCLOSURE	35-PLC-9005		
RS35PLC9006	1	Raceway		CS-35PLC9006	35-PLC-9000	35-PLC-9006		
RS35PLC9006A	3/4	Raceway		CS-35PLC9006A	IT NETWORK ENCLOSURE	35-PLC-9006		
RS40AE10004	3/4	Raceway		CV-40AE10004	40-AIT-10004	40-AE-10004		
RS40AE20004	3/4	Raceway		CV-40AE20004	40-AIT-20004	40-AE-20004		
RS40AIT10004	3/4	Raceway		CS-40AIT10004	35-PLC-9000	40-AIT-10004		
RS40AIT20004	3/4	Raceway		CS-40AIT20004	35-PLC-9000	40-AIT-20004		
RS40CV10012	3/4	Raceway		CS-40CV10012	35-PLC-9000	40-CV-10012		
RS40CV20012	3/4	Raceway		CS-40CV20012	35-PLC-9000	40-CV-20012		
RS40VCP10010	3/4	Raceway		CS-40VCP10010	35-PLC-9000	40-VCP-10010		
RS40VCP10020	3/4	Raceway		CS-40VCP10020	35-PLC-9000	40-VCP-10020		
RS40VCP20010	3/4	Raceway		CS-40VCP20010	35-PLC-9000	40-VCP-20010		
RS40VCP20020	3/4	Raceway		CS-40VCP20020	35-PLC-9000	40-VCP-20020		
RS50AE10131	3/4	Raceway		CV-50AE10131	50-AIT-10131	50-AE-10131		
RS50AE20131	3/4	Raceway		CV-50AE20131	50-AIT-20131	50-AE-20131		
RS50AIT10131	3/4	Raceway		CS-50AIT10131	35-PLC-9001	50-AIT-10131		
RS50AIT10141	3/4	Raceway		CS-50AIT10141	35-PLC-9001	50-AIT-10141		
RS50AIT20131	3/4	Raceway		CS-50AIT20131	35-PLC-9002	50-AIT-20131		
RS50AIT20141	3/4	Raceway		CS-50AIT20141	35-PLC-9002	50-AIT-20141		
RS50CV00013	3/4	Raceway		CS-50CV00013	70-PLC-9000	50-CV-00013		
RS50CV00023	3/4	Raceway		CS-50CV00023	70-PLC-9000	50-CV-00023		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS50CV10021	3/4	Raceway		CS-50CV10021	35-PLC-9001	50-CV-10021		
RS50CV10041	3/4	Raceway		CS-50CV10041	35-PLC-9001	50-CV-10041		
RS50CV10051	3/4	Raceway		CS-50CV10051	35-PLC-9001	50-CV-10051		
RS50CV20021	3/4	Raceway		CS-50CV20021	35-PLC-9002	50-CV-20021		
RS50CV20041	3/4	Raceway		CS-50CV20041	35-PLC-9002	50-CV-20041		
RS50CV20051	3/4	Raceway		CS-50CV20051	35-PLC-9000	50-CV-20051		
RS50CV30021	3/4	Raceway		CS-50CV30021	35-PLC-9000	35-CV-30021		
RS50CV30041	3/4	Raceway		CS-50CV30041	35-PLC-9000	50-CV-30041		
RS50CV30051	3/4	Raceway		CS-50CV30051	35-PLC-9000	35-CV-30051		
RS50CV40021	3/4	Raceway		CS-50CV40021	35-PLC-9000	35-CV-40021		
RS50CV40041	3/4	Raceway		CS-50CV40041	35-PLC-9000	50-CV-40041		
RS50CV40051	3/4	Raceway		CS-50CV40051	35-PLC-9000	35-CV-40051		
RS50CV50021	3/4	Raceway		CS-50CV50021	35-PLC-9000	35-CV-50021		
RS50CV50041	3/4	Raceway		CS-50CV50041	35-PLC-9000	50-CV-50041		
RS50CV50051	3/4	Raceway		CS-50CV50051	35-PLC-9000	35-CV-50051		
RS50CV60021	3/4	Raceway		CS-50CV60021	35-PLC-9000	35-CV-60021		
RS50CV60041	3/4	Raceway		CS-50CV60041	35-PLC-9000	50-CV-60041		
RS50CV60051	3/4	Raceway		CS-50CV60051	35-PLC-9000	35-CV-60051		
RS50FIT10010	3/4	Raceway		CS-50FIT10010	35-PLC-9001	50-FIT-10010		
RS50FIT20010	3/4	Raceway		CS-50FIT20010	35-PLC-9001	50-FIT-20010		
RS50LIT20111	3/4	Raceway		CS-50LIT20111	35-PLC-9002	50-LIT-20111		
RS50LIT30111	3/4	Raceway		CS-50LIT30111	35-PLC-9003	50-LIT-30111		
RS50LIT40111	3/4	Raceway		CS-50LIT40111	35-PLC-9004	50-LIT-40111		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS50LIT50111	3/4	Raceway		CS-50LIT50111	35-PLC-9005	50-LIT-50111		
RS50LIT60111	3/4	Raceway		CS-50LIT60111	35-PLC-9006	50-LIT-60111		
RS50LT00016	3/4	Raceway		CS-50LT00016	60-PLC-9000	50-LT-00016		
RS50LT10111	3/4	Raceway		CS-50LT10111	35-PLC-9001	50-LT-10111		
RS60LIT00012	3/4	Raceway		CS-60LIT00012	60-PLC-9000	60-LIT-00012		
RS70FIT00010	3/4	Raceway		CS-70FIT00010	70-PLC-9000	70-FIT-00010		
RS70FIT00013	3/4	Raceway		CS-70FIT00013	35-DP-00013	70-FIT-00013		
RS70FIT00020	3/4	Raceway		CS-70FIT00020	70-PLC-9000	70-FIT-00020		
RS70LIT10010	3/4	Raceway		CS-70LIT10010	70-PLC-9000	70-LIT-10010		
RS70LIT20010	3/4	Raceway		CS-70LIT20010	70-PLC-9000	70-LIT-20010		
RS70PIT00015	3/4	Raceway		CS-70PIT00015	35-DP-00013	70-PIT-00015		
RS70PLC9000A	2	Raceway	DB-01	CS-70PLC9000	ACC 2100	MH-01		
RS70PLC9000B	2	Raceway	DB-02	CS-70PLC9000	MH-01	MH-02		
RS70PLC9000C	2	Raceway	DB-03	CS-70PLC9000	MH-02	MH-03		
RS70PLC9000D	2	Raceway	DB-04	CS-70PLC9000	MH-03	70-PLC-9000		
RS70PLC9000E	3/4	Raceway		CS-70PLC9000A	IT NETWORK ENCLOSURE	70-PLC-9000		
RS70TIT00011	3/4	Raceway		CS-70TIT00011	70-PLC-9000	70-TIT-00011		
RS70TIT00014	3/4	Raceway		CS-70TIT00014	35-DP-00013	70-TIT-00014		
RS70TIT00021	3/4	Raceway		CS-70TIT00021	70-PLC-9000	70-TIT-00021		
RS71CV00013	3/4	Raceway		CS-71CV00013	70-PLC-9000	71-CV-00013		
RS71CV00023	3/4	Raceway		CS-71CV00023	70-PLC-9000	71-CV-00023		
RS71CV00033	3/4	Raceway		CS-71CV00033	70-PLC-9000	71-CV-00033		
RS71LCS00010	3/4	Raceway		CC-71LCS00010	RC71LCS00010	71-LCS-00010		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS71LCS00020	3/4	Raceway		CC-71LCS00020	RC71LCS00020	71-LCS-00020		
RS71LCS00030	3/4	Raceway		CC-71LCS00030	RC71LCS00030	71-LCS-00030		
RS73LCS00010	3/4	Raceway		CS-73LCS00010	MCC-2155	73-LCS-00010		
RS73LCS00020	3/4	Raceway		CS-73LCS00020	MCC-2155	73-LCS-00020		
RS84LIT00021	3/4	Raceway		CS-84LIT00021	60-PLC-9000	84-LIT-00021		
RS84VCP10010	3/4	Raceway		CS-84VCP10010	35-PLC-9000	84-VCP-10010		
RS84VCP20010	3/4	Raceway		CS-84VCP20010	35-PLC-9000	84-VCP-20010		
RS87PLC9000	3/4	Raceway		CS-87PLC9000	35-PLC-9000	87-PLC-9000		
RS89FIT00065	1	Raceway		CS-89FIT00065	ACC2101	89-FIT-00065		
RS89FIT00082	3/4	Raceway		CS-89FIT00082	ACC2101	89-FIT-00082		
RS89FIT00095	3/4	Raceway		CS-89FIT00095	ACC2101	89-FIT-00095		
RS89FIT00112	3/4	Raceway		CS-89FIT00112	ACC2101	89-FIT-00112		
RS89LIT00010	3/4	Raceway		CS-89LIT00010	ACC2101	89-LIT-00010		
RS89LIT00020	3/4	Raceway		CS-89LIT00020	ACC2101	89-LIT-00020		
RS89P00060	3/4	Raceway		CS-89P00060	ACC2101	89-P-00060		
RS89P00070	1-1/4	Raceway		CS-89P00070	ACC2101	89-P-00070		
RS89P00080	3/4	Raceway		CS-89P00080	ACC2101	89-P-00080		
RS89P00090	3/4	Raceway		CS-89P00090	ACC2101	89-P-00090		
RS89P00100	3/4	Raceway		CS-89P00100	ACC2101	89-P-00100		
RS89P00110	3/4	Raceway		CS-89P00110	ACC2101	89-P-00110		
RS89PI00031	3/4	Raceway		CS-89PI00031	PIT00031	PI00031		
RS89PIT00011	3/4	Raceway		CS-89PIT00011	ACC2101	89-PIT-00011		
RS89PIT00013	3/4	Raceway		CS-89PIT00013	ACC2101	89-PIT-00013		

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
RS89PIT00021	3/4	Raceway		CS-89PIT00021	ACC2101	89-PIT-00021		
RS89PIT00023	3/4	Raceway		CS-89PIT00023	ACC2101	89-PIT-00023		
RS89PIT00031	3/4	Raceway		CS-89PIT00031	ACC2101	PIT00031		
RS89PIT00041	3/4	Raceway		CS-89PIT00041	ACC2101	89-PIT-00041		
RS89PIT00051	3/4	Raceway		CS-89PIT00051	ACC2101	89-PIT-00051		
RS89PIT00061	3/4	Raceway		CS-89PIT00061	ACC2101	89-PIT-00061		
RS89PIT00071	1	Raceway		CS-89PIT00071	ACC2101	89-PIT-00071		
RS89PIT00081	3/4	Raceway		CS-89PIT00081	ACC2101	89-PIT-00081		
RS89PIT00091	3/4	Raceway		CS-89PIT00091	ACC2101	89-PIT-00091		
RS89PIT00101	3/4	Raceway		CS-89PIT00101	ACC2101	89-PIT-00101		
RS89PIT00111	3/4	Raceway		CS-89PIT00111	ACC2101	89-PIT-00111		
TC351001	18	Tray		CC-35MCC2155B				
TP351001	30	Tray		CP-2155PP08				
TP70CV00099	6	Tray		CP-70CV00099				
TP70CV00100	6	Tray		CP-70CV00100				
TP70CV10020	6	Tray		CP-70CV10020				
TP70CV20010	6	Tray		CP-70CV20010				
TP70CV20020	6	Tray		CP-70CV20020				
TS351001	30	Tray		CS-35PLC9000				
TS351002	9	Tray		CS-01FOPP01A				
				CS-01FOPP01B				
TS351003	12	Tray		CS-01FOPP01A				
				CS-01FOPP01B				
TS351004	12	Tray		CS-01FOPP01A				

CABLE TRAY/ RACEWAY TAG	SIZE (INCHES)	TRAY OR RACEWAY	DUCT BANK	CABLE NUMBERS	RACEWAY FROM	RACEWAY TO	COMMENTS	CONTRACT / REV
				CS-01FOPP01B				
TS351014	6	Tray		CS-01FOPP01A				
				CS-01FOPP01B				
TS352001	6	Tray		CS-01FOPP01A				
				CS-01FOPP01B				
				CS-35PLC9000				

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SECTION 26 06 20.24

ELECTRICAL CABLE SCHEDULE

PART 1 GENERAL

1.01 DESCRIPTION

A. Specifies the cable schedule for conductors and cables specified in Sections 26 05 19 and 26 05 13.

B. Schedule contains the following information:
   1. Cable number:
      a. A unique number assigned to a cable or group of conductors associated with a single piece of equipment and with the same from and to location.
   2. From and to the equipment designations in which the location cable is terminated at each end.
   3. Type of conductor and insulation defined and specified in the CABLESPEC sheets in Sections 26 05 19 and 26 05 13.
   4. Number of conductors, pairs, triads, and/or multiconductor cables.
      a. C = Conductors
      b. PR = Pair
      c. TR = Triad
   5. Cond Size:
      a. Size of each current carrying conductor in AWG or kCMIL.
   6. Grd Size:
      a. Size of the grounding conductor included in the cable.
   7. Via list of raceways through which the cable is routed between the From and To location of the utilization equipment.

1.02 CABLE NUMBERING

A. Cable numbers are prefixed for one or more of the following functions:

Cable prefix	Type of function
CC	Control and/or 120V or less power
CP	Power 208V to 600V
CS	Low level signal (less than 90V) communication or less than 30V instrumentation

B. Prefixes are followed by a three- or four-digit number. Where there is more than one cable associated with particular piece of equipment, a letter suffix may be added to distinguish the cables.
   1. Example:
      a. Cable number = CP30DS20010

2. Where:
    a. CP = power cable
3. 30 = 2 Digit area number
4. DS20010 = Equipment number
5. A = Letter to distinguish cable from other cables associated with the same equipment.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 CABLE SCHEDULE

A. The cable schedule consists of the following:

END OF SECTION

SALT LAKE CITY DEPT. OF PUBLIC UTILITIES
CITY CREEK TREATMENT PLAN UPGRADES
BRIC PACKAGE

Cable Schedule

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-70SWGR2140A	XHHW2	3#500, 1#350G	UTILITY TRANSFORMER	SWGR-2140	RP70SWGR2140A					70-E-	SWITCHGEAR GENERATOR FEED	
CP-70SWGR2140B	XHHW2	3#500, 1#350G	UTILITY TRANSFORMER	SWGR-2140	RP70SWGR2140B					70-E-	SWITCHGEAR GENERATOR FEED	
CP-70SWGR2140C	XHHW2	3#500, 1#350G	UTILITY TRANSFORMER	SWGR-2140	RP70SWGR2140C					70-E-	SWITCHGEAR GENERATOR FEED	
CP-70SWGR2140D	XHHW2	3#500, 1#350G	UTILITY TRANSFORMER	SWGR-2140	RP70SWGR2140D					70-E-	SWITCHGEAR GENERATOR FEED	
CP-30DS20010	TCER	3#10, 1#10G	MCC-2155	30-DS-20010	RP30DS20010A					35-E-11	FLOC INLET CHANNEL AGITATION PUMP	
CP-30P20010	XHHW2	3#10, 1#10G	30-DS-20010	30-P-20010	RP30P20010					35-E-11	FLOC INLET CHANNEL AGITATION PUMP	
CP-20DS20010	VFD1	3#12, 1#12G	MCC-2155	20-DS-20010	RP20DS20010					35-E-12	FLASH MIX PUMP 2	
CP-20P20010	VFD1	3#12, 1#12G	20-DS-20010	20-P-20010	RP20P20010					35-E-12	FLASH MIX PUMP 2	
CP-35DS00030	VFD1	3#12, 1#12G	MCC-2155	35-DS-00030	RP35DS00030					35-E-06	PLANT WATER PUMP 3	
CP-35P00030	VFD1	3#12, 1#12G	35-DS-00030	35-P-00030	RP35P00030					35-E-06	PLANT WATER PUMP 3	
CP-35DS00040	VFD1	3#12, 1#12G	MCC-2155	35-DS-00040	RP35DS00040					35-E-06	PLANT WATER PUMP 4	
CP-35P00040	VFD1	3#12, 1#12G	35-DS-00040	35-P-00040	RP35P00040					35-E-06	PLANT WATER PUMP 4	
CP-84DS00010	TCER	3#12, 1#12G	MCC-2155	84-DS-00010	RP84DS00010					35-E-07	NEAT PEA TRANSFER MIXING PUMP	
CP-84P00010	XHHW2	3#12, 1#12G	84-DS-00010	84-P-00010	RP84P00010					35-E-07	NEAT PEA TRANSFER MIXING PUMP	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-84DS00020	TCER	3#12, 1#12G	MCC-2155	84-DS-00020	RP84DS00020					35-E-07	PEA FEED PUMP 1	
CP-84P00020	XHHW2	3#12, 1#12G	84-DS-00020	84-P-00020	RP84P00020					35-E-07	PEA FEED PUMP 1	
CP-84DS00030	TCER	3#12, 1#12G	MCC-2155	84-DS-00030	RP84DS00030					35-E-07	PEA FEED PUMP 2	
CP-84P00030	XHHW2	3#12, 1#12G	84-DS-00030	84-P-00030	RP84P00030					35-E-07	PEA FEED PUMP 2	
CP-84DS00040	TCER	3#12, 1#12G	MCC-2155	84-DS-00040	RP84DS00040					35-E-07	PEA FEED PUMP 3	
CP-84P00040	XHHW2	3#12, 1#12G	84-DS-00040	84-P-00040	RP84P00040					35-E-07	PEA FEED PUMP 3	
CP-84DS00050	TCER	3#12, 1#12G	MCC-2155	84-DS-00050	RP84DS00050					35-E-07	PEA FEED PUMP 4	
CP-84P00050	XHHW2	3#12, 1#12G	84-DS-00050	84-P-00050	RP84P00050					35-E-07	PEA FEED PUMP 4	
CP-84DS00060	TCER	3#12, 1#12G	MCC-2155	84-DS-00060	RP84DS00060					35-E-07	PEA FEED PUMP 5	
CP-84P00060	XHHW2	3#12, 1#12G	84-DS-00060	84-P-00060	RP84P00060					35-E-07	PEA FEED PUMP 5	
CC-35LCP00100	XHHW2	36#14, 1#14G	35-PLC-9000	35-LCP-00100	RC35LCP00100					35-E-06	TREATMENT BUILDING DRAINAGE PUMP 1 & 2 LCP CONTROL	
CP-35LCP00100	TCER	3#12, 1#12G	MCC-2155	35-LCP-00100	RP35LCP00100					35-E-06	TREATMENT BUILDING DRAINAGE PUMP 1 & 2 LCP POWER	
CV-35P00100	VENDOR	Special	35-LCP-00100	35-P-00100	RP35P00100					35-E-06	TREATMENT BUILDING DRAINAGE PUMP 1	
CV-35P00110	VENDOR	Special	35-LCP-00100	35-P-00110	RP35P00110						TREATMENT BUILDING DRAINAGE PUMP 2	
CV-35LSH00101	VENDOR	Special	35-LCP-00100	35-LSH00101	RC35LSH00101						TREATMENT BUILDING DRAINAGE LEVEL SWITCH HIGH	
CV-35LSM00101	VENDOR	Special	35-LCP-00100	35-LSH00101	RC35LSH00101						TREATMENT BUILDING DRAINAGE LEVEL SWITCH MEDIUM	
CV-35LSL00101	VENDOR	Special	35-LCP-00100	35-LSH00101	RC35LSH00101						TREATMENT BUILDING DRAINIAGE LEVEL SWITCH LOW	
CC-35LCP00050	XHHW2	36#14, 1#14G	35-PLC-9000	35-LCP-00050	RC35LCP00050						TREATMENT BUILDING RECYCLE PUMP 1 AND 2 LCP CONTROL	
CP-35DS00050	TCER	3#12, 1#12G	MCC-2155	35-LCP-00050	RP35LCP00050					35-E-06	TREATMENT BUILDING RECYCLE PUMP 1 AND 2 LCP POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CV-35P00050	VENDOR	Special	35-LCP-00050	35-P-00050	RP35P00050					35-E-06	TREATMENT BUILDING RECYCLE PUMP 1	
CV-35P00060	VENDOR	Special	35-LCP-00050	35-P-00060	RP35P00060					35-E-06	TREATMENT BUILDING RECYCLE PUMP 2	
CV-35LSH00011	VENDOR	Special	35-LCP-00050	35-LSH00011	RC35LSH00011						TREATMENT BUILDING RECYCLE LEVEL SWITCH HIGH	
CV-35LSM00011	VENDOR	Special	35-LCP-00050	35-LSH00011	RC35LSH00011						TREATMENT BUILDING RECYCLE LEVEL SWITCH MEDIUM	
CV-35LSL00011	VENDOR	Special	35-LCP-00050	35-LSH00011	RC35LSH00011						TREATMENT BUILDING RECYCLE LEVEL SWITCH LOW	
CP-35P00090	XHHW2	2#12, 1#12G	2155-LP-03	35-P00090	RP35P00090						TREATMENT BUILDING RECYCLE PUMP 3 POWER	
CP-2155PP08	TCER	3#1, 1#6G	MCC-2155	2155-PP-08	TP351001					35-E-28	480V POWER PANEL	
CP-30DS11010	VFD1	3#12, 1#12G	MCC-2155	30-DS-11010	RP30DS11010					35-E-11	FLOCCULATOR 1A DISCONNECT POWER	
CP-30MX11010	VFD1	3#12, 1#12G	30-DS-11010	30-MX-11010	RP30MX11010					35-E-11	FLOCCULATOR 1A POWER	
CC-30LCP11010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-11010	RC30LCP11010						FLOCCULATOR 1A CONTROL	
CC-35MCC2155G	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155G						FLOCCULATOR 1A CONTROL	
CP-30DS11020	VFD1	3#12, 1#12G	MCC-2155	30-DS-11020	RP30DS11020					35-E-11	FLOCCULATOR 1B DISCONNECT POWER	
CP-30MX11020	VFD1	3#12, 1#12G	30-DS-11020	30-MX-11020	RP30MX11020					35-E-11	FLOCCULATOR 1B POWER	
CC-30LCP11020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-11020	RC30LCP11020						FLOCCULATOR 1B CONTROL	
CC-35MCC2155H	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155G						FLOCCULATOR 1B CONTROL	
CP-30DS12010	VFD1	3#12, 1#12G	MCC-2155	30-DS-12010	RP30DS12010					35-E-11	FLOCCULATOR 2A DISCONNECT POWER	
CP-30MX12010	VFD1	3#12, 1#12G	30-DS-12010	30-MX-12010	RP30MX12010					35-E-11	FLOCCULATOR 2A POWER	
CC-30LCP12010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-12010	RC30LCP12010						FLOCCULATOR 2A CONTROL	
CC-35MCC2155I	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155H						FLOCCULATOR 2A CONTROL	
CP-30DS12020	VFD1	3#12, 1#12G	MCC-2155	30-DS-12020	RP30DS12020					35-E-11	FLOCCULATOR 2B DISCONNECT POWER	
CP-30MX12020	VFD1	3#12, 1#12G	30-DS-12020	30-MX-12020	RP30MX12020					35-E-11	FLOCCULATOR 2B POWER	
CC-30LCP12020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-12020	RC30LCP12020						FLOCCULATOR 2B CONTROL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-35MCC2155J	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155H						FLOCCULATOR 2B CONTROL	
CP-30DS13010	VFD1	3#12, 1#12G	MCC-2155	30-DS-13010	RP30DS13010					35-E-11	FLOCCULATOR 3A DISCONNECT POWER	
CP-30MX13010	VFD1	3#12, 1#12G	30-DS-13010	30-MX-13010	RP30MX13010					35-E-11	FLOCCULATOR 3A POWER	
CC-30LCP13010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-13010	RC30LCP13010						FLOCCULATOR 3A CONTROL	
CC-35MCC2155K	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155I						FLOCCULATOR 3A CONTROL	
CP-30DS13020	VFD1	3#12, 1#12G	MCC-2155	30-DS-13020	RP30DS13020					35-E-11	FLOCCULATOR 3B DISCONNECT POWER	
CP-30MX13020	VFD1	3#12, 1#12G	30-DS-13020	30-MX-13020	RP30MX13020					35-E-11	FLOCCULATOR 3B POWER	
CC-30LCP13020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-13020	RC30LCP13020						FLOCCULATOR 3B CONTROL	
CC-35MCC2155L	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155I						FLOCCULATOR 3B CONTROL	
CP-30DS21010	VFD1	3#12, 1#12G	MCC-2155	30-DS-21010	RP30DS21010					35-E-11	FLOCCULATOR 1A DISCONNECT POWER	
CP-30MX21010	VFD1	3#12, 1#12G	30-DS-21010	30-MX-21010	RP30MX21010					35-E-11	FLOCCULATOR 1A POWER	
CC-30LCP21010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-21010	RC30LCP21010						FLOCCULATOR 1A CONTROL	
CC-35MCC2155M	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155J						FLOCCULATOR 1A CONTROL	
CP-30DS21020	VFD1	3#12, 1#12G	MCC-2155	30-DS-21020	RP30DS21020					35-E-11	FLOCCULATOR 1B DISCONNECT POWER	
CP-30MX21020	VFD1	3#12, 1#12G	30-DS-21020	30-MX-21020	RP30MX21020					35-E-11	FLOCCULATOR 1B POWER	
CC-30LCP21020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-21020	RC30LCP21020						FLOCCULATOR 1B CONTROL	
CC-35MCC2155N	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155J						FLOCCULATOR 1B CONTROL	
CP-30DS22010	VFD1	3#12, 1#12G	MCC-2155	30-DS-22010	RP30DS22010					35-E-11	FLOCCULATOR 2A	
CP-30MX22010	VFD1	3#12, 1#12G	30-DS-22010	30-MX-22010	RP30MX22010					35-E-11	FLOCCULATOR 2A	
CC-30LCP22010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-22010	RC30LCP22010						FLOCCULATOR 2A CONTROL	
CC-35MCC2155O	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155K						FLOCCULATOR 2A CONTROL	
CP-30DS22020	VFD1	3#12, 1#12G	MCC-2155	30-DS-22020	RP30DS22020					35-E-11	FLOCCULATOR 2B	
CP-30MX22020	VFD1	3#12, 1#12G	30-DS-22020	30-MX-22020	RP30MX22020					35-E-11	FLOCCULATOR 2B	
CC-30LCP22020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-22020	RC30LCP22020						FLOCCULATOR 2B CONTROL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-35MCC2155P	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155K						FLOCCULATOR 2B CONTROL	
CP-30DS23010	VFD1	3#12, 1#12G	MCC-2155	30-DS-23010	RP30DS23010					35-E-11	FLOCCULATOR 3A	
CP-30MX23010	VFD1	3#12, 1#12G	30-DS-23010	30-MX-23010	RP30MX23010					35-E-11	FLOCCULATOR 3A	
CC-30LCP23010	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-23010	RC30LCP23010						FLOCCULATOR 3A CONTROL	
CC-35MCC2155Q	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155L						FLOCCULATOR 3A CONTROL	
CP-30DS23020	VFD1	3#12, 1#12G	MCC-2155	30-DS-23020	RP30DS23020					35-E-11	FLOCCULATOR 3B	
CP-30MX23020	VFD1	3#12, 1#12G	30-DS-23020	30-MX-23020	RP30MX23020					35-E-11	FLOCCULATOR 3B	
CC-30LCP23020	XHHW2	10#14, 1#14G	MCC-2155	30-LCP-23020	RC30LCP23020						FLOCCULATOR 3B CONTROL	
CC-35MCC2155R	XHHW2	10#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155L						FLOCCULATOR 3B CONTROL	
CP-35DS00020A	TCER	3#12, 1#12G	MCC-2155	35-DS-00020A	RP35DS00020A					35-E-11		
CP-35EF00020	XHHW2	3#12, 1#12G	35-DS-00020	35-EF-00020	RP35EF00020					35-E-11		
CP-35DS00010A	TCER	3#12, 1#12G	MCC-2155	35-DS-00010A	RP35DS00010A					35-E-11		
CP-35EF00010	XHHW2	3#12, 1#12G	35-DS-00010A	35-EF-00010	RP35EF00010					35-E-11		
CP-35DS0001B	TCER	3#10, 1#10G	MCC-2155	35-DS-00010B	RP35DS00010B					35-E-07		
CP-35MAU00010	XHHW2	3#10, 1#10G	35-DS-00010B	35-MAU-00010	RP35MAU00010					35-E-07		
CP-87DS00010	TCER	3#12, 1#12G	MCC-2155	87-DS-00010	RP87DS00010					87-E-01		
CP-87MAU00010	XHHW2	3#12, 1#12G	87-DS-00010	87-MAU-00010	RP87MAU00010					87-E-01		
CP-70DS00010A	XHHW2	3#12, 1#12G	MCC-2155	70-DS-00010A	RP70DS00010A					70-E-04	TREATED WATER SAMPLE PUMP	
CP-70P00010	XHHW2	3#12, 1#12G	70-DS-00010A	70-P-00010	RP70P00010					70-E-04	TREATED WATER SAMPLE PUMP	
CC-70PSH00011	XHHW2	2#14, 1#14G	MCC-2155	70-PSH-00011	RC70PSH00011					70-E-04	TREATED WATER SAMPLE PUMP PRESSURE SWITCH	
CC-70LCS00010	XHHW2	10#14, 1#14G	MCC-2155	70-LCS-00010	RC70LCS00010					70-E-04	TREATED WATER SAMPLE PUMP LCS CONTROLS	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-70DS00010B	XHHW2	3#12, 1#12G	MCC-2160	70-DS-00010B	RP70DS00010B					70-E-03	BACKWASH PUMP STATION INLET SLIDE GATE	
CP-70P00010	XHHW2	3#12, 1#12G	70-DS-00010B	70-GT-00010	RP70GT00010					70-E-03	BACKWASH PUMP STATION INLET SLIDE GATE	
CP-70DS10010A	XHHW2	3#12, 1#12G	MCC-2160	70-DS-10010A	RP70DS10010A					70-E-03	CLEARWELL 1 INLET GATE	
CP-70GT10010	XHHW2	3#12, 1#12G	70-DS-10010A	70-GT-10010	RP70GT10010					70-E-03	CLEARWELL 1 INLET GATE	
CP-70DS10020A	XHHW2	3#12, 1#12G	MCC-2160	70-DS-10020A	RP70DS10020A					70-E-03	CLEARWELL 1 OUTLET GATE 1	
CP-70GT10020	XHHW2	3#12, 1#12G	70-DS-10020A	70-GT-10020	RP70GT10020					70-E-03	CLEARWELL 1 OUTLET GATE 1	
CP-70DS10030	XHHW2	3#12, 1#12G	MCC-2160	70-DS-10030	RP70DS10030					70-E-03	CLEARWELL 1 OUTLET GATE 2	
CP-70GT10030	XHHW2	3#12, 1#12G	70-DS-10030	70-GT-10030	RP70GT10030					70-E-03	CLEARWELL 1 OUTLET GATE 2	
CP-70DS20010A	XHHW2	3#12, 1#12G	MCC-2160	70-DS-20010A	RP70DS20010A					70-E-03	CLEARWELL 2 INLET GATE	
CP-70GT20010	XHHW2	3#12, 1#12G	70-DS-20010A	70-GT-20010	RP70GT20010					70-E-03	CLEARWELL 2 INLET GATE	
CP-70DS20020A	XHHW2	3#12, 1#12G	MCC-2160	70-DS-20020A	RP70DS20020A					70-E-03	CLEARWELL 2 OUTLET GATE 1	
CP-70GT20020	XHHW2	3#12, 1#12G	70-DS-20020A	70-GT-20020	RP70GT20020					70-E-03	CLEARWELL 2 OUTLET GATE 1	
CP-70DS20030	XHHW2	3#12, 1#12G	MCC-2160	70-DS-20030	RP70DS20030					70-E-03	CLEARWELL 2 OUTLET GATE 2	
CP-70GT20030	XHHW2	3#12, 1#12G	70-DS-20030	70-GT-20030	RP70GT20030					70-E-03	CLEARWELL 2 OUTLET GATE 2	
CP-70LCP00020	TCER	3#12, 1#12G	MCC-2160	70-LCP-00020	RP70LCP00020					70-E-03	CLEARWELL STRUCTRAL UNDERDRAIN PUMP 1 & 2 LCP POWER	
CV-70P00020	VENDOR	Special	70-DS-00020A	70-P-00020	RP70P00020					70-E-03	CLEARWELL STRUCTRAL UNDERDRAIN PUMP 1	
CV-70P00030	VENDOR	Special	70-DS-00030	70-P-00030	RP70P00030					70-E-03	CLEARWELL STRUCTRAL UNDERDRAIN PUMP 2	
CC-70LCP00020	XHHW2	36#14, 1#14G	70-PLC-9000	70-LCP-00020	RC70LCP00020						CLEARWELL STRUCTRAL UNDERDRAIN PUMP 1 & 2 LCP CONTROLS	
CV-70LSH00017	XHHW2	2#14, 1#14G	70-LCP-00020	70-LSH-00017	RC70LSH00017						CLEARWELL STRUCTRAL UNDERDRAIN LEVEL SWITCH HIGH	
CV-70LSM00017	XHHW2	2#14, 1#14G	70-LCP-00020	70-LSH-00017	RC70LSH00017						CLEARWELL STRUCTRAL UNDERDRAIN LEVEL SWITCH MEDIUM	

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CV-70LSL00017	XHHW2	2#14, 1#14G	70-LCP-00020	70-LSH-00017	RC70LSH00017						CLEARWELL STRUCTRAL UNDERDRAIN LEVEL SWITCH LOW	
CP-70DS00010C	XHHW2	3#10, 1#10G	MCC-2160	70-DS-00010C	RP70DS00010C					70-E-03		
CP-70MAU00010	XHHW2	3#10, 1#10G	70-DS-00010C	70-MAU-00010	RP70MAU00010					70-E-03		
CP-70DS00010D	XHHW2	3#12, 1#12G	MCC-2160	70-DS-00010D	RP70DS00010D					70-E-03		
CP-70EF00010	XHHW2	3#12, 1#12G	70-DS-00010D	70-EF-00010	RP70EF00010					70-E-03		
CP-70DS00020B	XHHW2	3#12, 1#12G	MCC-2160	70-DS-00020B	RP70DS00020B					70-E-07	PUMP ROOM EXHAUST FAN	
CP-70EF00020	XHHW2	3#12, 1#12G	70-DS-00020B	70-EF-00020	RP70EF00020					70-E-07	PUMP ROOM EXHAUST FAN	
CP-71VFD00020	VFD2	3#4/0, 3#2G	MCC-2160	71-VFD-00020	RP71VFD00020					70-E-07	BACKWASH SUPPLY PUMP 2	
CP-71DS00020	VFD2	3#4/0, 3#2G	71-VFD-00020	71-DS-00020	RP71DS00020					70-E-07	BACKWASH SUPPLY PUMP 2	
CP-71P00020	VFD2	3#4/0, 3#2G	71-DS-00020	71-P-00020	RP71P00020					70-E-07	BACKWASH SUPPLY PUMP 2	
CC-35MCC2155A	TCER	8#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155A					35-E-26	RAW WATER SAMPLE PUMP	
CC-35LCS0010	TCER	8#14, 1#14G	MCC-2155	35-LCS-0010	RC35LCS0010					35-E-12	RAW WATER SAMPLE PUMP	
CC-35PSL00012	TCER	2#14, 1#14G	MCC-2155	35-PSL-00012	RC35PSL00012					35-E-12	RAW WATER SAMPLE PUMP	
CS-35FIT00011	INS	1PR #16SH	35-PLC-9000	35-FIT-00011	CS35FIT00011							
CC-35MCC2155B	TCER	18#14, 1#14G	35-PLC-9000	MCC-2155	TC351001					35-E-26	FLOCCULATION INLET CHANNEL AGITATION PUMP	
CC-30P20010	TCER	2#14, 1#14G	MCC-2155	30-P-20010	RC30P20010					35-E-33	FLOCCULATION INLET CHANNEL AGITATION PUMP	
CP-70MCC2155A	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP70MCC2150A					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	
CP-70MCC2155B	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP01MCC2150B					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	
CP-70MCC2155C	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP01MCC2150C					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	

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CP-70MCC2155D	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP70MCC2150D					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	
CP-70MCC2155E	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP70MCC2150E					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	
CP-70MCC2155F	XHHW2	3#400, 1#2/0G	SWGR-2140	MCC-2155	RP70MCC2150F					35-E-34	TREATMENT BUILDING SWGR TO TREATMENT MCC	
CP-01ATS	XHHW2	3#350, 1#1/0G	SWGR-2140	ATS	RP01ATS					01-E-02	OPERATIONS BUILDING ATS	
CP-01SWGR2140A	XHHW2	3#4/0, 1#2G	SWGR-2140	CLARIFIER	RP01SWGR2140A					01-E-02	TREATMENT BUILDING TO CLAIFIER	
CS-01FOPP01A	FOTSM	24 FiberSM	ACC 2100	FOPP-01	RS01FOPP01A	MH-01	RS01FOPP01B	MH-02	RS01FOPP01C	01-E-03	OPERATIONS BUILDING NETWORK TO TREATMENT PATCH PANEL	
CS-01FOPP01A	FOTSM	24 FiberSM	ACC 2100	FOPP-01	TS351014	TS351004	TS351003	TS351002	TS352001	35-E-07	OPERATIONS BUILDING NETWORK TO TREATMENT PATCH PANEL	
CS-01FOPP01B	FOTSM	24 FiberSM	ACC 2100	FOPP-01	RS01FOPP01A	MH-01	RS01FOPP01B	MH-02	RS01FOPP01C	01-E-03	OPERATIONS BUILDING NETWORK TO TREATMENT PATCH PANEL	
CS-01FOPP01B	FOTSM	24 FiberSM	ACC 2100	FOPP-01	TS351014	TS351004	TS351003	TS351002	TS352001	35-E-07	OPERATIONS BUILDING NETWORK TO TREATMENT PATCH PANEL	
CS-70PLC9000	FOTSM	24 FiberSM	ACC 2100	70-PLC-9000	RS70PLC9000A	MH-01	RS70PLC9000B	MH-02	RS70PLC9000C	01-E-03	OPERATIONS BUILDING NETWORK TO CLEARWELL NETWORK	
CS-70PLC9000	FOTSM	24 FiberSM	ACC 2100	70-PLC-9000	MH-03	RS70PLC9000D				01-E-03	OPERATIONS BUILDING NETWORK TO CLEARWELL NETWORK	
CS-35PLC9000	FOTSM	24 FiberSM	FOPP-01	35-PLC-9000	RS35PLC9000	TS352001	TS351001			35-E-28	TREATMENT PATCH PANEL TO TREATMENT PLC CABINET	
CS-87PLC9000	FOTSM	24 FiberSM	35-PLC-9000	87-PLC-9000	RS87PLC9000					35-E-34	TREATMENT PLC CABINET TO FLUORIDE PLC CABINET	
CP-50DS10011	TCER	3#12, 1#12G	2155-PP-01	50-DS-10011	RP50DS10011					35-E-06	FILTER 1 INLET VALVE DISCONNECT POWER	
CP-50CV10011	XHHW2	3#12, 1#12G	50-DS-10011	50-CV-10011	RP50CV10011					35-E-06	FILTER 1 INLET VALVE POWER	
CC-50CV10011	XHHW2	18#14, 1#14G	35-PLC-9001	50-CV-10011	RC50CV10011						FILTER 1 INLET VALVE CONTROL	
CP-35WH00001	TCER	3#12, 1#12G	2155-LP-02	35-WH-00001	RP35WH00001					35-E-11	FLOC BASIN BATHROOM WATER HEATER POWER	
CP-40VCP10010	TCER	2#12, 1#12G	2155-LP-03	40-VCP-10010	RP40VCP10010					35-E-09	SOLIDS COLLECTOR 1A VENDOR CONTROL PANEL POWER	
CP-40COL10010	XHHW2	2#12, 1#12G	40-VCP-10010	40-COL-10010	RP40COL10010					35-E-09	SOLIDS COLLECTOR 1A POWER	

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CC-40VCP10010	TCER	11#14, 1#14G	35-PLC-9000	40-VCP-10010	RC40VCP10010					35-E-09	SOLIDS COLLECTOR 1A CONTROLS	
CS-40VCP10010	INSM	2PR #16SH	35-PLC-9000	40-VCP-10010	RS40VCP10010					35-E-09	SOLIDS COLLECTOR 1A CONTROLS	
CC-40SV10001	XHHW2	2#12, 1#12G	35-PLC-9000	40-SV-10001	RC40SV10001						SOLIDS COLLECTOR 1A SOLINOID VALVE	
CP-40VCP10020	TCER	2#12, 1#12G	2155-LP-03	40-VCP-10020	RP40VCP10020					35-E-09	SOLIDS COLLECTOR 1B CONTROL PANEL POWER	
CP-40COL10020	XHHW2	2#12, 1#12G	40-VCP-10020	40-COL-10020	RP40COL10020					35-E-09	SOLIDS COLLECTOR 1B POWER	
CC-40VCP10020	TCER	11#14, 1#14G	35-PLC-9000	40-VCP-10020	RC40VCP10020					35-E-09	SOLIDS COLLECTOR 1B CONTROLS	
CS-40VCP10020	INSM	2PR #16SH	35-PLC-9000	40-VCP-10020	RS40VCP10020						SOLIDS COLLECTOR 1B SIGNAL	
CP-40VCP20010	TCER	2#12, 1#12G	2155-LP-03	40-CVCP-20010	RP40VCP20010					35-E-09	SOLIDS COLLECTOR 2A DISCONNECT POWER	
CP-40COL20010	XHHW2	2#12, 1#12G	40-CVCP-20010	40-COL-20010	RP40COL20010					35-E-09	SOLIDS COLLECTOR 2A POWER	
CC-40VCP20010	TCER	11#14, 1#14G	35-PLC-9000	40-VCP-20010	RC40VCP20010					35-E-09	SOLIDS COLLECTOR 2A CONTROLS	
CS-40VCP20010	INSM	2PR #16SH	35-PLC-9000	40-VCP-20010	RS40VCP20010					35-E-09	SOLIDS COLLECTOR 2A SIGNAL	
CC-40SV20001	XHHW2	2#14, 1#14G	35-PLC-9000	40-SV-20001	RC40SV20001						SOLIDS COLLECTOR 2A SOLINOID VALVE	
CP-40VCP20020	TCER	2#12, 1#12G	2155-LP-03	40-VCP-20020	RP40VCP20020					35-E-09	SOLIDS COLLECTOR 2B DISCONNECT POWER	
CP-40COL20020	XHHW2	2#12, 1#12G	40-VCP-20020	40-COL-20020	RP40COL20020					35-E-09	SOLIDS COLLECTOR 2B POWER	
CC-40VCP20020	TCER	11#14, 1#14G	35-PLC-9000	40-VCP-20020	RC40VCP20020					35-E-09	SOLIDS COLLECTOR 2B CONTROLS	
CS-40VCP20020	INSM	2PR #16SH	35-PLC-9000	40-VCP-20020	RS40VCP20020					35-E-09	SOLIDS COLLECTOR 2B SIGNAL	
CP-40CV10011	TCER	3#12, 1#12G	2155-PP-01	40-DS-10011	RP40DS10011					35-E-09	SOLIDS COLLECTOR VALVE 1A DISCONNECT POWER	
CP-40CV10011	TCER	3#12, 1#12G	40-DS-10011	40-CV-10011	RP40CV10011					35-E-09	SOLIDS COLLECTOR VALVE 1A POWER	
CC-40CV10011	TCER	18#14, 1#14G	35-LCP-9000	40-CV-10011	RC40CV10011					35-E-09	SOLIDS COLLECTOR VALVE 1A CONTROL	
CP-40DS10021	TCER	3#12, 1#12G	2155-PP-01	40-DS-10021	RP40DS10021					35-E-09	SOLIDS COLLECTOR VALVE 1B DISCONNECT POWER	
CP-40CV10021	XHHW2	3#12, 1#12G	40-DS-10021	40-CV-10021	RP40CV10021					35-E-09	SOLIDS COLLECTOR VALVE 1B POWER	
CC-40CV10021	TCER	18#14, 1#14G	35-LCP-9000	40-CV-10021	RC40CV10021					35-E-09	SOLIDS COLLECTOR VALVE 1B CONTROLS	
CP-40DS20011	TCER	3#12, 1#12G	2155-PP-02	40-DS-20011	RP40DS20011					35-E-09	SOLIDS COLLECTOR VALVE 2A DISCONNECT POWER	
CP-40CV20011	XHHW2	3#12, 1#12G	40-DS-20011	40-CV-20011	RP40CV20011					35-E-09	SOLIDS COLLECTOR VALVE 2A POWER	
CC-40CV20011	TCER	18#14, 1#14G	35-LCP-9000	40-CV-20011	RC40CV20011					35-E-09	SOLIDS COLLECTOR VALVE 2A CONTROLS	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-40DS20021	TCER	3#12, 1#12G	2155-PP-02	40-DS-20021	RP40DS20021					35-E-09	SOLIDS COLLECTOR VALVE 2B DISCONNECT POWER	
CP-40CV20021	XHHW2	3#12, 1#12G	40-DS-20021	40-CV-20021	RP40CV20021					35-E-09	SOLIDS COLLECTOR VALVE 2B POWER	
CC-40CV20021	TCER	18#14, 1#14G	35-LCP-9000	40-CV-20021	RC40CV20021					35-E-09	SOLIDS COLLECTOR VALVE 2B CONTROL	
CP-50DS10041	TCER	3#12, 1#12G	2155-PP-01	50-DS-10041	RP50DS10041					35-E-07	FILTER 1 WASTE BACKWASH WATER VALVE DISCONNECT POWER	
CP-50CV10041	XHHW2	3#12, 1#12G	50-DS-10041	50-CV-10041	RP50CV10041					35-E-07	FILTER 1 WASTE BACKWASH WATER VALVE POWER	
CC-50CV10041	TCER	8#14, 1#14G	35-PLC-9001	50-CV-10041	RC50CV10041					35-E-07	FILTER 1 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV10041	INSM	2PR #18SH	35-PLC-9001	50-CV-10041	RS50CV10041					35-E-07	FILTER 1 WASTE BACKWASH WATER VALVE SIGNAL	
CP-50DS10051	TCER	3#12, 1#12G	2155-PP-01	50-DS-10051	RP50DS10051					35-E-07	FILTER 1 WASTE VALVE DISCONNECT POWER	
CP-50CV10051	XHHW2	3#12, 1#12G	50-DS-10051	50-CV-10051	RP50CV10051					35-E-07	FILTER 1 WASTE VALVE VALVE POWER	
CC-50CV10051	TCER	8#14, 1#14G	35-PLC-9001	50-CV-10051	RC50CV10051					35-E-07	FILTER 1 WASTE VALVE CONTROL	
CS-50CV10051	INSM	2PR #18SH	35-PLC-9001	50-CV-10051	RS50CV10051					35-E-07	FILTER 1 WASTE VALVE SIGNAL	
CP-50DS10021	TCER	3#12, 1#12G	2155-PP-01	50-DS-10021	RP50DS10021					35-E-07	FILTER 1 OUTLET VALVE DISCONNECT POWER	
CP-50CV10021	XHHW2	3#12, 1#12G	50-DS-10021	50-CV-10021	RP50CV10021					35-E-07	FILTER 1 OUTLET VALVE POWER	
CC-50CV10021	TCER	8#14, 1#14G	35-PLC-9001	50-CV-10021	RC50CV10021					35-E-07	FILTER 1 OUTLET VALVECONTROL	
CS-50CV10021	INSM	2PR #18SH	35-PLC-9001	50-CV-10021	RS50CV10021					35-E-07	FILTER 1 OUTLET VALVE SIGNAL	
CP-50CV30041	TCER	3#12, 1#12G	2155-PP-03	50-CV-30041	RP50CV30041					35-E-07	FILTER 3 WASTE BACKWASH WATER VALVE POWER	
CC-50CV30041	TCER	8#14, 1#14G	35-PLC-9000	50-CV-30041	RC50CV30041					35-E-07	FILTER 3 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV30041	INSM	2PR #18SH	35-PLC-9000	50-CV-30041	RS50CV30041					35-E-07	FILTER 3 WASTE BACKWASH WATER VALVE SIGNAL	
CP-50CV30011	TCER	3#12, 1#12G	2155-PP-03	50-CV-30011	RP50CV30011					35-E-07	FILTER 3 INLET VALVE POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-50CV30011	TCER	18#14, 1#14G	35-PLC-9000	50-CV-30011	RC50CV30011					35-E-07	FILTER 3 INLET VALVE CONTROL	
CP-50CV50041	TCER	3#12, 1#12G	2155-PP-05	50-CV-50041	RP50CV50041					35-E-07	FILTER 5 WASTE BACKWASH WATER VALVE POWER	
CC-50CV50041	TCER	8#14, 1#14G	35-PLC-9000	50-CV-50041	RC50CV50041					35-E-07	FILTER 5 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV50041	INSM	2PR #18SH	35-PLC-9000	50-CV-50041	RS50CV50041					35-E-07	FILTER 5 WASTE BACKWASH WATER VALVE SIGNAL	
CP-50CV50011	TCER	3#12, 1#12G	2155-PP-05	50-CV-50011	RP50CV50011					35-E-07	FILTER 5 INLET VALVE POWER	
CC-50CV50011	TCER	18#14, 1#14G	35-PLC-9000	50-CV-50011	RC50CV50011					35-E-07	FILTER 5 INLET VALVE CONTROL	
CP-50DS20041	TCER	3#12, 1#12G	2155-PP-02	50-DS-20041	RP50DS20041					35-E-07	FILTER 2 WASTE BACKWASH WATER VALVE POWER	
CP-50CV20041	XHHW2	3#12, 1#12G	50-DS-20041	50-CV-20041	RP50CV20041					35-E-07	FILTER 2 WASTE BACKWASH WATER VALVE POWER	
CC-50CV20041	TCER	8#14, 1#14G	35-PLC-9002	50-CV-20041	RC50CV20041					35-E-07	FILTER 2 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV20041	INSM	2PR #18SH	35-PLC-9002	50-CV-20041	RS50CV20041					35-E-07	FILTER 2 WASTE BACKWASH WATER VALVE SIGNAL	
CP-50DS20011	TCER	3#12, 1#12G	2155-PP-02	50-DS-20011	RP50DS20011					35-E-07	FILTER 2 INLET VALVE POWER	
CP-50CV20011	XHHW2	3#12, 1#12G	50-DS-20011	50-CV-20011	RP50CV20011					35-E-07	FILTER 2 INLET VALVE POWER	
CC-50CV20011	TCER	18#14, 1#14G	35-PLC-9002	50-CV-20011	RC50CV20011					35-E-07	FILTER 2 INLET VALVE CONTROL	
CP-50CV40041	TCER	3#12, 1#12G	2155-PP-04	50-CV-40041	RP50CV40041					35-E-07	FILTER 4 WASTE BACKWASH WATER VALVE POWER	
CC-50CV40041	TCER	8#14, 1#14G	35-PLC-9000	50-CV-40041	RC50CV40041					35-E-07	FILTER 4 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV40041	INSM	2PR #18SH	35-PLC-9000	50-CV-40041	RS50CV40041					35-E-07	FILTER 4 WASTE BACKWASH WATER VALVE SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-50CV40011	TCER	3#12, 1#12G	2155-PP-04	50-CV-40011	RP50CV40011					35-E-07	FILTER 4 INLET VALVE POWER	
CC-50CV40011	TCER	18#14, 1#14G	35-PLC-9000	50-CV-40011	RC50CV40011					35-E-07	FILTER 4 INLET VALVE CONTROL	
CP-50CV60041	TCER	3#12, 1#12G	2155-PP-06	50-CV-60041	RP50CV60041					35-E-07	FILTER 6 WASTE BACKWASH WATER VALVE POWER	
CC-50CV60041	TCER	8#14, 1#14G	35-PLC-9000	50-CV-60041	RC50CV60041					35-E-07	FILTER 6 WASTE BACKWASH WATER VALVE CONTROL	
CS-50CV60041	INSM	2PR #18SH	35-PLC-9000	50-CV-60041	RS50CV60041					35-E-07	FILTER 6 WASTE BACKWASH WATER VALVE SIGNAL	
CP-50CV60011	TCER	3#12, 1#12G	2155-PP-06	50-CV-60011	RP50CV60011					35-E-07	FILTER 6 INLET VALVE POWER	
CC-50CV60011	TCER	18#14, 1#14G	35-PLC-9000	50-CV-60011	RC50CV60011					35-E-07	FILTER 6 INLET VALVE CONTROL	
CC-84FSL00014	TCER	2#14, 1#14G	35-PLC-9000	84-FSL-00014	RC84FSL00014					35-E-07	EMERGENCY EYEWASH STATION 00010 FLOW SWITCH	
CS-35FIT00018	INS	1PR #16SH	35-PLC-9000	35-FIT-00018	RS35FIT00018					35-E-06		
CP-35CV00019	TCER	3#12, 1#12G	2155-PP-05	35-CV-00019	RP35CV00019					35-E-06	MASTER BACKWASH FLOW CONTROL VALVE 2 POWER	
CC-35CV00019	TCER	8#14, 1#14G	35-PLC-9000	35-CV-00019	RC35CV00019					35-E-06	MASTER BACKWASH FLOW CONTROL VALVE 2 CONTROL	
CS-35CV00019	INSM	2PR #18SH	35-PLC-9000	35-CV-00019	RS35CV00019					35-E-06	MASTER BACKWASH FLOW CONTROL VALVE 2 SIGNAL	
CP-50DS10031	TCER	3#12, 1#12G	2155-PP-01	35-DS-10031	RP50DS10031						FILTER 1 BACKWASH VALVE DISCONNECT POWER	
CP-50CV10031	XHHW2	3#12, 1#12G	35-DS-10031	35-CV-10031	RP50CV10031						FILTER 1 BACKWASH VALVE POWER	
CC-50CV10031	TCER	18#14, 1#14G	35-PLC-9000	35-CV-10031	RC50CV10031						FILTER 1 BACKWASH VALVE CONTROLS	
CV-50CS10031	TCER	18#14, 1#14G	35-CV-10031	35-CS-10031	RC50CS10031						FILTER 1 BACKWASH VALVE CONTROLS	
CP-50DS10061	TCER	3#12, 1#12G	2155-PP-01	50-DS-10061	RP50DS10061						FILTER 1 AIR WASH VALVE DISCONNECT POWER	
CP-50CV10061	TCER	3#12, 1#12G	35-DS-10061	50-CV-10061	RP50CV10061						FILTER 1 AIR WASH VALVE POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-50CV10061	TCER	18#14, 1#14G	35-PLC-9001	50-CV-10061	RC50CV10061						FILTER 1 AIR WASH VALVE CONTROLS	
CP-50DS20021	TCER	3#12, 1#12G	2155-PP-02	50-DS-20021	RP50DS20021						FILTER 2 OUTLET VALVE POWER	
CP-50CV20021	XHHW2	3#12, 1#12G	50-DS-20021	50-CV-20021	RP50CV20021						FILTER 2 OUTLET VALVE POWER	
CC-50CV20021	TCER	8#14, 1#14G	35-PLC-9002	50-CV-20021	RC50CV20021						FILTER 2 OUTLET VALVE CONTROLS	
CS-50CV20021	INSM	2PR #18SH	35-PLC-9002	50-CV-20021	RS50CV20021						FILTER 2 OUTLET VALVE SIGNALS	
CP-50DS20031	TCER	3#12, 1#12G	2155-PP-02	50-DS-20031	RP50DS20031						FILTER 2 BACKWASH VALVE DISCONNECT POWER	
CP-50CV20031	XHHW2	3#12, 1#12G	50-DS-20031	50-CV-20031	RP50CV20031						FILTER 2 BACKWASH VALVE POWER	
CC-50CV20031	TCER	18#14, 1#14G	35-PLC-9002	50-CV-20031	RC50CV20031						FILTER 2 BACKWASH VALVE CONTROLS	
CV-50CS20031	XHHW2	18#14, 1#14G	35-PLC-9002	50-CS-20031	RC50CS20031						FILTER 2 BACKWASH VALVE CONTROLS	
CP-50DS20051	TCER	3#12, 1#12G	2155-PP-02	50-DS-20051	RP50DS20051						FILTER 2 FILTER TO WASTE VALVE POWER	
CP-50CV20051	XHHW2	3#12, 1#12G	50-DS-20051	50-CV-20051	RP50CV20051						FILTER 2 FILTER TO WASTE VALVE POWER	
CC-50CV20051	TCER	8#14, 1#14G	35-PLC-9000	50-CV-20051	RC50CV20051						FILTER 2 FILTER TO WASTE VALVE CONTROLS	
CS-50CV20051	INSM	2PR #18SH	35-PLC-9000	50-CV-20051	RS50CV20051						FILTER 2 FILTER TO WASTE VALVE SIGNALS	
CP-50DS20061	TCER	3#12, 1#12G	2155-PP-02	50-DS-20061	RP50DS20061						FILTER 2 AIR WASH VALVE POWER	
CP-50CV20061	XHHW2	3#12, 1#12G	50-DS-20061	50-CV-20061	RP50CV20061						FILTER 2 AIR WASH VALVE POWER	
CC-50CV20061	TCER	18#14, 1#14G	35-PLC-9002	50-CV-20061	RC50CV20061						FILTER 2 AIR WASH VALVE CONTROLS	
CP-50CV30021	TCER	3#12, 1#12G	2155-PP-03	35-CV-30021	RP50CV30021						FILTER 3 OUTLET VALVE POWER	
CC-50CV30021	TCER	8#14, 1#14G	35-PLC-9000	35-CV-30021	RC50CV30021						FILTER 3 OUTLET VALVE CONTROLS	
CS-50CV30021	INSM	2PR #18SH	35-PLC-9000	35-CV-30021	RS50CV30021						FILTER 3 OUTLET VALVE SIGNALS	
CP-50CV30031	TCER	3#12, 1#12G	2155-PP-03	35-CV-30031	RP50CV30031						FILTER 3 BACKWASH VALVE POWER	
CC-50CV30031	TCER	18#14, 1#14G	35-PLC-9000	35-CV-30031	RC50CV30031						FILTER 3 BACKWASH VALVE CONTROLS	
CP-50CV30051	TCER	3#12, 1#12G	2155-PP-03	35-CV-30051	RP50CV30051						FILTER 3 FILTER TO WASTE VALVE POWER	
CC-50CV30051	TCER	8#14, 1#14G	35-PLC-9000	35-CV-30051	RC50CV30051						FILTER 3 FILTER TO WASTE VALVE CONTROLS	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CS-50CV30051	INSM	2PR #18SH	35-PLC-9000	35-CV-30051	RS50CV30051						FILTER 3 FILTER TO WASTE VALVE SIGNALS	
CP-50CV30061	TCER	3#12, 1#12G	2155-PP-03	35-CV-30061	RP50CV30061						FILTER 3 AIR WASH VALVE POWER	
CC-50CV30061	TCER	18#14, 1#14G	35-PLC-9000	35-CV-30061	RC50CV30061						FILTER 3 AIR WASH VALVE CONTROLS	
CP-50CV40021	TCER	3#12, 1#12G	2155-PP-04	35-CV-40021	RP50CV40021						FILTER 4 OUTLET VALVE POWER	
CC-50CV40021	TCER	8#14, 1#14G	35-PLC-9000	35-CV-40021	RC50CV40021						FILTER 4 OUTLET VALVE CONTROLS	
CS-50CV40021	INSM	2PR #18SH	35-PLC-9000	35-CV-40021	RS50CV40021						FILTER 4 OUTLET VALVE SIGNALS	
CP-50CV40031	TCER	3#12, 1#12G	2155-PP-04	35-CV-40031	RP50CV40031						FILTER 4 BACKWASH VALVE POWER	
CC-50CV40031	TCER	18#14, 1#14G	35-PLC-9000	35-CV-40031	RC50CV40031						FILTER 4 BACKWASH VALVE CONTROLS	
CP-50CV40051	TCER	3#12, 1#12G	2155-PP-04	35-CV-40051	RP50CV40051						FILTER 4 FILTER TO WASTE VALVE POWER	
CC-50CV40051	TCER	8#14, 1#14G	35-PLC-9000	35-CV-40051	RC50CV40051						FILTER 4 FILTER TO WASTE VALVE CONTROLS	
CS-50CV40051	INSM	2PR #18SH	35-PLC-9000	35-CV-40051	RS50CV40051						FILTER 4 FILTER TO WASTE VALVE SIGNALS	
CP-50CV40061	TCER	3#12, 1#12G	2155-PP-04	35-CV-40061	RP50CV40061						FILTER 4 AIR WASH VALVE POWER	
CC-50CV40061	TCER	18#14, 1#14G	35-PLC-9000	35-CV-40061	RC50CV40061						FILTER 4 AIR WASH VALVE CONTROLS	
CP-50CV50021	TCER	3#12, 1#12G	2155-PP-05	35-CV-50021	RP50CV50021						FILTER 5 OUTLET VALVE POWER	
CC-50CV50021	TCER	8#14, 1#14G	35-PLC-9000	35-CV-50021	RC50CV50021						FILTER 5 OUTLET VALVE CONTROLS	
CS-50CV50021	INSM	2PR #18SH	35-PLC-9000	35-CV-50021	RS50CV50021						FILTER 5 OUTLET VALVE SIGNALS	
CP-50CV50031	TCER	3#12, 1#12G	2155-PP-05	35-CV-50031	RP50CV50031						FILTER 5 BACKWASH VALVE POWER	
CC-50CV50031	TCER	18#14, 1#14G	35-PLC-9000	35-CV-50031	RC50CV50031						FILTER 5 BACKWASH VALVE CONTROLS	
CP-50CV50051	TCER	3#12, 1#12G	2155-PP-05	35-CV-50051	RP50CV50051						FILTER 5 FILTER TO WASTE VALVE POWER	
CC-50CV50051	TCER	8#14, 1#14G	35-PLC-9000	35-CV-50051	RC50CV50051						FILTER 5 FILTER TO WASTE VALVE CONTROLS	
CS-50CV50051	INSM	2PR #18SH	35-PLC-9000	35-CV-50051	RS50CV50051						FILTER 5 FILTER TO WASTE VALVE SIGNALS	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-50CV50061	TCER	3#12, 1#12G	2155-PP-05	35-CV-50061	RP50CV50061						FILTER 5 AIR WASH VALVE POWER	
CC-50CV50061	TCER	18#14, 1#14G	35-PLC-9000	35-CV-50061	RC50CV50061						FILTER 5 AIR WASH VALVE CONTROLS	
CP-50CV60021	TCER	3#12, 1#12G	2155-PP-06	35-CV-60021	RP50CV60021						FILTER 6 OUTLET VALVE POWER	
CC-50CV60021	TCER	8#14, 1#14G	35-PLC-9000	35-CV-60021	RC50CV60021						FILTER 6 OUTLET VALVE CONTROLS	
CS-50CV60021	INSM	2PR #18SH	35-PLC-9000	35-CV-60021	RS50CV60021						FILTER 6 OUTLET VALVE SIGNALS	
CP-50CV60031	TCER	3#12, 1#12G	2155-PP-06	35-CV-60031	RP50CV60031						FILTER 6 BACKWASH VALVE POWER	
CC-50CV60031	TCER	18#14, 1#14G	35-PLC-9000	35-CV-60031	RC50CV60031						FILTER 6 BACKWASH VALVE CONTROLS	
CP-50CV60051	TCER	3#12, 1#12G	2155-PP-06	35-CV-60051	RP50CV60051						FILTER 6 FILTER TO WASTE VALVE POWER	
CC-50CV60051	TCER	8#14, 1#14G	35-PLC-9000	35-CV-60051	RC50CV60051						FILTER 6 FILTER TO WASTE VALVE CONTROLS	
CS-50CV60051	INSM	2PR #18SH	35-PLC-9000	35-CV-60051	RS50CV60051						FILTER 6 FILTER TO WASTE VALVE SIGNALS	
CP-50CV60061	TCER	3#12, 1#12G	2155-PP-06	35-CV-60061	RP50CV60061						FILTER 6 AIR WASH VALVE POWER	
CC-50CV60061	TCER	18#14, 1#14G	35-PLC-9000	35-CV-60061	RC50CV60061						FILTER 6 AIR WASH VALVE CONTROLS	
CP-60LIT00012	XHHW2	3#12, 1#12G	60-LP-CLARIFIER	60-LIT-00012	RP60LIT00012						CLARIFIER LEVEL TRANSMITTER POWER	
CS-60LIT00012	INSM	2PR #18SH	60-PLC-9000	60-LIT-00012	RS60LIT00012						CLARIFIER LEVEL TRANSMITTER SIGNAL	
CC-60PPCLARIFIER	XHHW2	8#14, 1#14G	60-PLC-9000	60-PP-CLARIFIER	RC60PPCLARIFIER						WASTE BACKWASH WATER CLARIFIER MOTOR CONTROLS	
CC-60LCS00013	XHHW2	8#14, 1#14G	60-PP-CLARIFIER	60-LCS-00013	RC60LCS00013						WASTE BACKWASH WATER CLARIFIER MOTOR CONTROLS	
CP-60DS00013	XHHW2	3#12, 1#12G	60-PP-CLARIFIER	60-DS-00013	RP60DS00013						WASTE BACKWASH WATER CLARIFIER MOTOR POWER	
CP-60CL00013	XHHW2	3#12, 1#12G	60-DS-00013	60-CL-00013	RP60CL00013						WASTE BACKWASH WATER CLARIFIER MOTOR POWER	
CC-60CV00030	XHHW2	18#14, 1#14G	60-PLC-9000	60-CV-00030	RC60CV00030						CLARIFIER DECANT VALVE 1 CONTROLS	
CP-60CV00030	XHHW2	3#12, 1#12G	60-PP-CLARIFIER	60-CV-00030	RP60CV00030						CLARIFIER DECANT VALVE 1 POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-60CV00031	XHHW2	18#14, 1#14G	60-PLC-9000	60-CV-00031	RC60CV00031						CLARIFIER DECANT VALVE 2 CONTROLS	
CP-60CV00031	XHHW2	3#12, 1#12G	60-PP-CLARIFIER	60-CV-00031	RP60CV00031						CLARIFIER DECANT VALVE 2 POWER	
CC-60CV00032	XHHW2	18#14, 1#14G	60-PLC-9000	60-CV-00032	RC60CV00032						CLARIFIER SOLIDS VALVE 1 CONTROLS	
CP-60CV00032	XHHW2	3#12, 1#12G	60-PP-CLARIFIER	60-CV-00032	RP60CV00032						CLARIFIER SOLIDS VALVE 1 POWER	
CC-60LSH-00014	XHHW2	2#14, 1#14G	60-TJB-00010	60-LSH-00014	RC60LSH00014						CLARIFIER RAW WATER PUMP STATION LEVEL SWITCH HIGH	
CC-60LSM-00014	XHHW2	2#14, 1#14G	60-TJB-00010	60-LSH-00014	RC60LSH00014						CLARIFIER RAW WATER PUMP STATION LEVEL SWITCH MEDIUM	
CC-60LSL-00014	XHHW2	2#14, 1#14G	60-TJB-00010	60-LSH-00014	RC60LSH00014						CLARIFIER RAW WATER PUMP STATION LEVEL SWITCH LOW	
CC-60TJB00010	XHHW2	6#14, 1#14G	ACC-2300	60-TJB-00010	RC60TJB00010						CLARIFIER RAW WATER PUMP STATION LEVEL SWITCHS	
CP-60TJB00010A	VFD1	3#8, 1#8G	60-PP-CLARIFIER	60-TJB-00010	RP60TJB00010						CLARIFIER RAW WATER RECYCLE PUMP 1	
CP-60TJB00010B	VFD1	3#8, 1#8G	60-PP-CLARIFIER	60-TJB-00010	RP60TJB00010						CLARIFIER RAW WATER RECYCLE PUMP 2	
CV-60P00010	VENDOR	Special	60-TJB-00020	60-P-00010	RP60P00010						CLARIFIER RAW WATER RECYCLE PUMP 1	
CV-60P00020	VENDOR	Special	60-TJB-00020	60-P-00020	RP60P00020						CLARIFIER RAW WATER RECYCLE PUMP 2	
CP-87CU	XHHW2	3#12, 1#12G	87-LP-2271	87-CU	RP87CU						FLUORIDE BUILDING CONDENSING UNIT POWER	
CP-87EF	XHHW2	3#12, 1#12G	87-LP-2271	87-EF	RP87EF						FLUORIDE BUILDING EXHAUST FAN POWER	
CP-87MAU	XHHW2	3#12, 1#12G	87-LP-2271	87-MAU	RP87MAU						FLUORIDE BUILDING MAKE-UP AIR UNIT POWER	
CP-35CU-00010	XHHW2	2#8, 1#10G	2155-LP-02	35-CU-00010	RP35CU00010					70-E-05	SPLIT SYSTEM OUTDOOR UNIT 1 POWER	
CP-35SS-00010	XHHW2	2#8, 1#10G	35-CU-00010	35-SS-00010	RP35SS00010					70-E-05	SPLIT SYSTEM INDOOR UNIT 1 POWER	
CP-35F-00010	XHHW2	1#12, 1#12N, 1#12G	2155-LP-02	35-F-00010	RP35F00010					70-E-05	HVAC FURNACE 1 POWER	
CP-35CU-00020	XHHW2	2#8, 1#10G	2155-LP-03	35-CU-00020	RP35CU00020					70-E-05	SPLIT SYSTEM OUTDOOR UNIT 2 POWER	
CP-35SS-00020	XHHW2	2#8, 1#10G	35-CU-00020	35-SS-00020	RP35SS00020					70-E-05	SPLIT SYSTEM INDOOR UNIT 2 POWER	
CP-35F-00020	XHHW2	1#12, 1#12N, 1#12G	2155-LP-03	35-F-00020	RP35F00020					70-E-05	HVAC FURNACE 2 POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-35CU-00030	XHHW2	2#10, 1#10G	2155-LP-02	35-CU-00030	RP35CU00030					70-E-05	SPLIT SYSTEM OUTDOOR UNIT 3 POWER	
CP-35SS-00030	XHHW2	2#10, 1#10G	35-CU-00030	35-SS-00030	RP35SS00030					70-E-05	SPLIT SYSTEM INDOOR UNIT 3 POWER	
CP-35F-00030	XHHW2	1#12, 1#12N, 1#12G	2155-LP-02	35-F-00030	RP35F00030					70-E-05	HVAC FURNACE 3 POWER	
CP-35CU-00040	XHHW2	2#10, 1#10G	2155-LP-03	35-CU-00040	RP35CU00040					70-E-05	SPLIT SYSTEM OUTDOOR UNIT 4 POWER	
CP-35SS-00040	XHHW2	2#10, 1#10G	35-CU-00040	35-SS-00040	RP35SS00040					70-E-05	SPLIT SYSTEM INDOOR UNIT 4 POWER	
CP-35F-00040	XHHW2	1#12, 1#12N, 1#12G	2155-LP-03	35-F-00040	RP35F00040					70-E-05	HVAC FURNACE 4 POWER	
CP-70DS00060	XHHW2	3#12, 1#12G	MCC-2155	70-DS-00060	RP70DS00060					70-E-04	CARRIER WATER PUMP 1 DISCONNECT POWER	
CP-70P00060	XHHW2	3#12, 1#12G	70-DS-00060	70-P-00060	RP70P00060					70-E-04	CARRIER WATER PUMP 1 POWER	
CC-70LCS00060	XHHW2	10#14, 1#14G	MCC-2155	70-LCS-00060	RC70LCS00060					70-E-04	CARRIER WATER PUMP 1 LCS CONTROLS	
CP-70DS00070	XHHW2	3#12, 1#12G	MCC-2155	70-DS-00070	RP70DS00070					70-E-04	CARRIER WATER PUMP 2 DISCONNECT POWER	
CP-70P00070	XHHW2	3#12, 1#12G	70-DS-00070	70-P-00070	RP70P00070					70-E-04	CARRIER WATER PUMP 2 POWER	
CC-70LCS00070	XHHW2	10#14, 1#14G	MCC-2155	70-LCS-00070	RC70LCS00070					70-E-04	CARRIER WATER PUMP 2 LCS CONTROLS	
CC-73LCS00010	XHHW2	10#14, 1#14G	MCC-2155	73-LCS-00010	RC73LCS00010					70-E-04	PLANT WATER PUMP 1 LCS CONTROLS	
CS-73LCS00010	INSM	2PR #18SH	MCC-2155	73-LCS-00010	RS73LCS00010					70-E-04	PLANT WATER PUMP 1 LCS SIGNAL	
CP-73DS00010	XHHW2	3#8, 1#10G	MCC-2155	73-DS-00010	RP73DS00010					70-E-04	PLANT WATER PUMP 1 DISCONNECT POWER	
CP-73P00010	XHHW2	3#8, 1#10G	73-DS-00010	73-P-00010	RP73P00010					70-E-04	PLANT WATER PUMP 1 POWER	
CC-73TSH00011	XHHW2	2#14, 1#14G	MCC-2155	73-TSH-00011	RC73TSH00011					70-E-04	PLANT WATER PUMP 1 TEMPERATURE SWITCH	
CC-73LCS00020	XHHW2	10#14, 1#14G	MCC-2155	73-LCS-00020	RC73LCS00020					70-E-04	PLANT WATER PUMP 2 LCS CONTROLS	
CS-73LCS00020	INSM	2PR #18SH	MCC-2155	73-LCS-00020	RS73LCS00020					70-E-04	PLANT WATER PUMP 2 LCS SIGNAL	
CP-73DS00020	XHHW2	3#8, 1#10G	MCC-2155	73-DS-00020	RP73DS00020					70-E-04	PLANT WATER PUMP 2 DISCONNECT POWER	
CP-73P00020	XHHW2	3#8, 1#10G	73-DS-00020	73-P-00020	RP73P00020					70-E-04	PLANT WATER PUMP 2 POWER	
CC-73TSH00021	XHHW2	2#14, 1#14G	MCC-2155	73-TSH-00021	RC73TSH00021					70-E-04	PLANT WATER PUMP 2 TEMPERATURE SWITCH	
CP-70DSCRN	XHHW2	3#6, 1#10G	MCC-2155	70-DS-CRN	RP70DSCRN					70-E-05	AREA 70 CRANE DISCONNECT POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-70B00010	XHHW2	3#2, 1#6G	70-DS-00010E	70-B-00010	RP70B00010					70-E-32	BLOWER 1 POWER	
CP-70DS00010E	TCER	3#2, 1#2N, 1#6G	MCC-2155	70-DS-00010E	RP70DS00010E					70-E-32	BLOWER 1 DISCONNECT POWER	
CC-70VMP00010E	TCER	36#14, 1#14G	MCC-2155	70-VMP-00010	RC70VMP00010					70-E-32	BLOWER 1 LCS CONTROLS	
CP-70B00020	XHHW2	3#350, 1#4G	70-DS-00020E	70-B-00020	RP70B00020					70-E-32	BLOWER 2 POWER	
CP-70DS00020E	TCER	3#350, 1#3G	MCC-2155	70-DS-00020E	RP70DS00020E					70-E-32	BLOWER 2 DISCONNECT POWER	
CC-70VMP00020E	TCER	36#14, 1#14G	MCC-2155	70-VMP-00020	RC70VMP00020					70-E-32	BLOWER 2 LCS CONTROLS	
CC-73CV00013	TCER	18#14, 1#14G	70-PLC-9000	73-CV-00013	RC73CV00013					70-E-04	PLANT WATER PUMP 1 VALVE CONTROL	
CP-73DS00013	TCER	3#12, 1#12G	2155-PP-02	73-DS-00013	RP73DS00013					70-E-04	PLANT WATER PUMP 1 VALVE DISCONNECT POWER	
CP-73CV00013	TCER	3#12, 1#12G	73-DS-00013	73-CV-00013	RP73CV00013					70-E-04	PLANT WATER PUMP 1 VALVE POWER	
CC-73CV00023	TCER	18#14, 1#14G	70-PLC-9000	73-CV-00023	RC73CV00023					70-E-04	PLANT WATER PUMP 2 VALVE CONTROL	
CP-73DS00023	TCER	3#12, 1#12G	2155-PP-02	73-DS-00023	RP73DS00023					70-E-04	PLANT WATER PUMP 2 VALVE DISCONNECT POWER	
CP-73CV00023	TCER	3#12, 1#12G	73-DS-00023	73-CV-00023	RP73CV00023					70-E-04	PLANT WATER PUMP 2 VALVE POWER	
CC-71CV00017	TCER	18#14, 1#14G	70-PLC-9000	71-CV-00017	RC71CV00017					70-E-04	BACKWASH TANK VALVE CONTROL	
CP-71CV00017	TCER	3#12, 1#12G	2155-PP-01	71-CV-00017	RP71CV00017					70-E-04	BACKWASH TANK VALVE POWER	
CC-71CV00013	TCER	8#14, 1#14G	70-PLC-9000	71-CV-00013	RC71CV00013					70-E-04	BACKWASH PUMP 1 VALVE CONTROL	
CP-71CV00013	TCER	3#12, 1#12G	2155-PP-01	71-CV-00013	RP71CV00013					70-E-04	BACKWASH PUMP 1 VALVE POWER	
CS-71CV00013	INSM	2PR #18SH	70-PLC-9000	71-CV-00013	RS71CV00013					70-E-04	BACKWASH PUMP 1 VALVE SIGNAL	
CC-71CV00023	TCER	8#14, 1#14G	70-PLC-9000	71-CV-00023	RC71CV00023					70-E-04	BACKWASH PUMP 2 VALVE CONTROL	
CP-71CV00023	TCER	3#12, 1#12G	2155-PP-01	71-CV-00023	RP71CV00023					70-E-04	BACKWASH PUMP 2 VALVE POWER	
CS-71CV00023	INSM	2PR #18SH	70-PLC-9000	71-CV-00023	RS71CV00023					70-E-04	BACKWASH PUMP 2 VALVE SIGNAL	
CC-71CV00033	TCER	8#14, 1#14G	70-PLC-9000	71-CV-00033	RC71CV00033					70-E-04	BACKWASH PUMP 3 VALVE CONTROL	
CP-71CV00033	TCER	3#12, 1#12G	2155-PP-01	71-CV-00033	RP71CV00033					70-E-04	BACKWASH PUMP 3 VALVE POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CS-71CV00033	INSM	2PR #18SH	70-PLC-9000	71-CV-00033	RS71CV00033					70-E-04	BACKWASH PUMP 3 VALVE SIGNAL	
CC-71TSH00011	TCER	2#14, 1#14G	MCC-2155	71-TSH-00011	RC71RSH00011					70-E-04	BACKWASH PUMP 1 TEMPERATURE SWITCH	
CP-71VFD00010	TCER	3#4/0, 1#4G	MCC-2155	71-VFD-00010	RP71VFD00010					70-E-04	BACKWASH PUMP 1 VFD POWER	
CP-71	TCER	3#4/0, 1#4G	71-VFD-00010	71-DS-00010	RP71DS00010						BACKWASH PUMP 1 DISCONNECT POWER	
CP-71P00010	XHHW2	3#4/0, 1#4G	71-DS-00010	71-P-00010	RP71P00010					70-E-04	BACKWASH PUMP 1 POWER	
CC-71LCS00010	TCER	11#14, 1#14G	MCC-2155	71-LCS-00010	RC71LCS00010					70-E-04	BACKWASH PUMP 1 LCS CONTROL	
CC-71LCS00010	INSM	2PR #18SH	MCC-2155	71-LCS-00010	RS71LCS00010					70-E-04	BACKWASH PUMP 1 LCS SIGNAL	
CC-71TSH00021	TCER	2#14, 1#14G	MCC-2155	71-TSH-00021	RC71RSH00021					70-E-04	BACKWASH PUMP 2 TEMPERATURE SWITCH	
CC-71LCS00020	TCER	11#14, 1#14G	MCC-2155	71-LCS-00020	RC71LCS00020					70-E-04	BACKWASH PUMP 2 LCS CONTROL	
CC-71LCS00020	INSM	2PR #18SH	MCC-2155	71-LCS-00020	RS71LCS00020					70-E-04	BACKWASH PUMP 2 LCS SIGNAL	
CC-71TSH00031	TCER	2#14, 1#14G	MCC-2155	71-TSH-00031	RC71RSH00031					70-E-04	BACKWASH PUMP 3 TEMPERATURE SWITCH	
CP-71VFD00030	TCER	3#4/0, 1#4G	MCC-2155	71-VFD-00030	RP71VFD00030					70-E-04	BACKWASH PUMP 3 VFD POWER	
CP-71DS00030	TCER	3#4/0, 1#4G	71-VFD-00030	71-DS-00030	RP71DS00030						BACKWASH PUMP 3 DISCONNECT POWER	
CP-71P00030	XHHW2	3#4/0, 1#4G	71-DS-00030	71-P-00030	RP71P00030					70-E-04	BACKWASH PUMP 3 POWER	
CC-71LCS00030	TCER	11#14, 1#14G	MCC-2155	71-LCS-00030	RC71LCS00030					70-E-04	BACKWASH PUMP 3 LCS CONTROL	
CC-71LCS00030	INSM	2PR #18SH	MCC-2155	71-LCS-00030	RS71LCS00030					70-E-04	BACKWASH PUMP 3 LCS SIGNAL	
CS-70FIT00010	INS	1PR #18SH	70-PLC-9000	70-FIT-00010	RS70FIT00010					70-E-04	CLEARWELL FIT 1 SIGNAL	
CP-70FIT00010	XHHW2	3#12, 1#12G	2155-LP-01	70-FIT-00010	RP70FIT00010					70-E-04	CLEARWELL FIT 1 POWER	
CS-70FIT00020	INS	1PR #18SH	70-PLC-9000	70-FIT-00020	RS70FIT00020					70-E-04	CLEARWELL FIT 2 SIGNAL	
CP-70FIT00020	XHHW2	3#12, 1#12G	2155-LP-02	70-FIT-00020	RP70FIT00020					70-E-04	CLEARWELL FIT 2 POWER	
CP-70DS10010	TCER	3#12, 1#12G	2155-PP-03	70-DS-10010	RP70DS10010					70-E-04	CLEARWELL 1 INLET VALVE DISCONNECT POWER	
CP-70CV10010	XHHW2	3#12, 1#12G	70-DS-10010	70-CV-10010	RP70CV10010					70-E-04	CLEARWELL 1 INLET VALVE POWER	
CC-70CV10010	TCER	18#14, 1#14G	70-PLC-9000	70-CV-10010	RC70CV10010					70-E-04	CLEARWELL 1 INLET VALVE CONTROLS	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-70DS10020	TCER	3#12, 1#12G	2155-PP-03	70-DS-10020	RP70DS10020					70-E-04	CLEARWELL 1 OUTLET VALVE DISCONNECT POWER	
CP-70CV10020	XHHW2	3#12, 1#12G	70-DS-10020	70-CV-10020	TP70CV10020					70-E-04	CLEARWELL 1 OUTLET VALVE POWER	
CC-70CV10020	TCER	18#14, 1#14G	70-PLC-9000	70-CV-10020	RC70CV10020					70-E-04	CLEARWELL 1 OUTLET VALVE CONTROLS	
CP-70DS20010	TCER	3#12, 1#12G	2155-PP-04	70-DS-20010	RP70DS20010					70-E-04	CLEARWELL 2 INLET VALVE DISCONNECT POWER	
CP-70CV20010	XHHW2	3#12, 1#12G	70-DS-20010	70-CV-20010	TP70CV20010					70-E-04	CLEARWELL 2 INLET VALVE POWER	
CC-70CV20010	TCER	18#14, 1#14G	70-PLC-9000	70-CV-20010	RC70CV20010					70-E-04	CLEARWELL 2 INLET VALVE CONTROLS	
CP-70DS20020	TCER	3#12, 1#12G	2155-PP-04	70-DS-20020	RP70DS20020					70-E-04	CLEARWELL 2 OUTLET VALVE DISCONNECT POWER	
CP-70CV20020	XHHW2	3#12, 1#12G	70-DS-20020	70-CV-20020	TP70CV20020					70-E-04	CLEARWELL 2 OUTLET VALVE POWER	
CC-70CV20020	TCER	18#14, 1#14G	70-PLC-9000	70-CV-20020	RC70CV20020					70-E-04	CLEARWELL 2 OUTLET VALVE CONTROLS	
CP-70DS00099	TCER	3#12, 1#12G	2155-PP-05	70-DS-00099	RP70DS00099					70-E-04	CLEARWELL FINISHED WATER VALVE 1 DISCONNECT POWER	
CP-70CV00099	XHHW2	3#12, 1#12G	70-DS-00099	70-CV-00099	TP70CV00099					70-E-04	CLEARWELL FINISHED WATER VALVE 1 POWER	
CC-70CV00099	TCER	18#14, 1#14G	70-PLC-9000	70-CV-00099	RC70CV00099					70-E-04	CLEARWELL FINISHED WATER VALVE 1 CONTROLS	
CP-70DS00100	TCER	3#12, 1#12G	2155-PP-05	70-DS-00100	RP70DS00100					70-E-04	CLEARWELL FINISHED WATER VALVE 2 DISCONNECT POWER	
CP-70CV00100	XHHW2	3#12, 1#12G	70-DS-00100	70-CV-00100	TP70CV00100					70-E-04	CLEARWELL FINISHED WATER VALVE 2 POWER	
CC-70CV00100	TCER	18#14, 1#14G	70-PLC-9000	70-CV-00100	RC70CV00100					70-E-04	CLEARWELL FINISHED WATER VALVE 2 CONTROLS	
CP-50LT00016	XHHW2	3#12, 1#12G	2155-LP-01	50-LT-00016	RP50LT00016					35-E-07	FILTER INLET CHANNEL LEVEL POWER	
CS-50LT00016	INSM	2PR #18SH	60-PLC-9000	50-LT-00016	RS50LT00016					35-E-07	FILTER INLET CHANNEL LEVEL SIGNAL	
CP-84LIT00021	XHHW2	3#12, 1#12G	2155-LP-02	84-LIT-00021	RP84LIT00021					35-E-XX	ANIONIC POLYMER BATCH TANK LEVEL	
CS-84LIT00021	INSM	2PR #18SH	60-PLC-9000	84-LIT-00021	RS84LIT00021					35-E-XX	ANIONIC POLYMER BATCH TANK LEVEL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CS-35PLC9001	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9001	RS35PLC9001					35-E-07	FILTER 1 PLC	
CS-35PLC9003	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9003	RS35PLC9003					35-E-07	FILTER 3 PLC	
CS-35PLC9005	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9005	RS35PLC9005					35-E-07	FILTER 5 PLC	
CS-35PLC9002	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9002	RS35PLC9002					35-E-07	FILTER 2 PLC	
CS-35PLC9004	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9004	RS35PLC9004					35-E-07	FILTER 4 PLC	
CS-35PLC9006	NC4	1#600V CAT6A	35-PLC-9000	35-PLC-9006	RS35PLC9006					35-E-07	FILTER 6 PLC	
CP-50LIT10111	XHHW2	3#12, 1#12G	2155-LP-01	50-LT-10111	RP50LT10111					35-E-07	FILTER 1 LEVEL POWER	
CS-50LIT10111	INSM	2PR #18SH	35-PLC-9001	50-LT-10111	RS50LT10111					35-E-07	FILTER 1 LEVEL SIGNAL	
CP-50LIT30111	XHHW2	3#12, 1#12G	2155-LP-03	50-LIT-30111	RP50LIT30111					35-E-07	FILTER 3 LEVEL POWER	
CS-50LIT30111	INSM	2PR #18SH	35-PLC-9003	50-LIT-30111	RS50LIT30111					35-E-07	FILTER 3 LEVEL SIGNAL	
CP-50LIT50111	XHHW2	3#12, 1#12G	2155-LP-05	50-LIT-50111	RP50LIT50111					35-E-07	FILTER 5 LEVEL POWER	
CS-50LIT50111	INSM	2PR #18SH	35-PLC-9005	50-LIT-50111	RS50LIT50111					35-E-07	FILTER 5 LEVEL SIGNAL	
CP-50LIT20111	XHHW2	3#12, 1#12G	2155-LP-02	50-LIT-20111	RP50LIT20111					35-E-07	FILTER 2 LEVEL POWER	
CS-50LIT20111	INSM	2PR #18SH	35-PLC-9002	50-LIT-20111	RS50LIT20111					35-E-07	FILTER 2 LEVEL SIGNAL	
CP-50LIT40111	XHHW2	3#12, 1#12G	2155-LP-04	50-LIT-40111	RP50LIT40111					35-E-07	FILTER 4 LEVEL POWER	
CS-50LIT40111	INSM	2PR #18SH	35-PLC-9004	50-LIT-40111	RS50LIT40111					35-E-07	FILTER 4 LEVEL SIGNAL	
CP-50LIT60111	TCER	3#12, 1#12G	2155-LP-06	50-LIT-60111	RP50LIT60111					35-E-07	FILTER 6 LEVEL POWER	
CS-50LIT60111	INSM	2PR #18SH	35-PLC-9006	50-LIT-60111	RS50LIT60111					35-E-07	FILTER 6 LEVEL SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-84VCP10010	TCER	3#12, 1#12G	2155-PP-06	84-VCP-10010	RP84VCP10010					35-E-XX	POLYMER BLENDING UNIT 1 CONTROL PANEL POWER	
CC-84VCP10010	TCER	8#14, 1#14G	35-PLC-9000	84-VCP-10010	RC84VCP10010					35-E-XX	POLYMER BLENDING UNIT 1 CONTROL PANEL CONTROL	
CS-84VCP10010	INSM	2PR #18SH	35-PLC-9000	84-VCP-10010	RS84VCP10010					35-E-XX	POLYMER BLENDING UNIT 1 CONTROL PANEL SIGNAL	
CP-84VCP20010	TCER	3#12, 1#12G	2155-PP-06	84-VCP-20010	RP84VCP20010					35-E-XX	POLYMER BLENDING UNIT 2 CONTROL PANEL POWER	
CC-84VCP20010	TCER	8#14, 1#14G	35-PLC-9000	84-VCP-20010	RC84VCP20010					35-E-XX	POLYMER BLENDING UNIT 2 CONTROL PANEL CONTROL	
CS-84VCP20010	INSM	2PR #18SH	35-PLC-9000	84-VCP-20010	RS84VCP20010					35-E-XX	POLYMER BLENDING UNIT 2 CONTROL PANEL SIGNAL	
CS-35PLC9000A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9000	RS35PLC9000A					35-E-23	FILTER AREA PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9001A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9001	RS35PLC9001A					35-E-07	FILTER 1 PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9003A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9003	RS35PLC9003A					35-E-07	FILTER 3 PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9005A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9005	RS35PLC9005A					35-E-07	FILTER 5 PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9002A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9002	RS35PLC9002A					35-E-07	FILTER 2 PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9004A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9004	RS35PLC9004A					35-E-07	FILTER 4 PLC TO IT NETWORK ENCLOSURE	
CS-35PLC9006A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	35-PLC-9006	RS35PLC9006A					35-E-07	FILTER 6 PLC TO IT NETWORK ENCLOSURE	
CS-70PLC9000A	NC4	1#600V CAT6A	IT NETWORK ENCLOSURE	70-PLC-9000	RS70PLC9000E					35-E-23	CLEARWELL PLC TO IT NETWORK ENCLOSURE	
CP-70LIT10010	XHHW2	3#12, 1#12G	2155-LP-03	70-LIT-10010	RP70LIT10010					70-E-32	CLEARWELL 1 LEVEL POWER	
CS-70LIT10010	INSM	2PR #18SH	70-PLC-9000	70-LIT-10010	RS70LIT10010					70-E-32	CLEARWELL 1 LEVEL SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-70LIT20010	XHHW2	3#12, 1#12G	2155-LP-03	70-LIT-20010	RP70LIT20010					70-E-04	CLEARWELL 2 LEVEL POWER	
CS-70LIT20010	INSM	2PR #18SH	70-PLC-9000	70-LIT-20010	RS70LIT20010					70-E-04	CLEARWELL 2 LEVEL SIGNAL	
CS-35DP00013A	INSM	2PR #18SH	70-PLC-9000	35-DP-00013	RS35DP00013					70-E-32	BLOWERS OUTLET TEMPERATURE	
CS-70TIT00014	INSM	2PR #18SH	35-DP-00013	70-TIT-00014	RS70TIT00014					70-E-32	BLOWERS OUTLET TEMPERATURE	
CS-35DP00013B	INSM	2PR #18SH	70-PLC-9000	35-DP-00013	RS35DP00013A					70-E-32	BLOWERS OUTLET PRESSURE	
CS-70PIT00015	INSM	2PR #18SH	35-DP-00013	70-PIT-00015	RS70PIT00015					70-E-32	BLOWERS OUTLET PRESSURE	
CS-35DP00013C	INSM	2PR #18SH	70-PLC-9000	35-DP-00013	RS35DP00013					70-E-32	BLOWERS OUTLET FLOW	
CS-70FIT00013	INSM	2PR #18SH	35-DP-00013	70-FIT-00013	RS70FIT00013					70-E-32	BLOWERS OUTLET FLOW	
CS-70TIT00011	INSM	2PR #18SH	70-PLC-9000	70-TIT-00011	RS70TIT00011					70-E-32	BLOWER 1 INLET TEMPERATURE	
CS-70TIT00021	INSM	2PR #18SH	70-PLC-9000	70-TIT-00021	RS70TIT00021					70-E-32	BLOWER 2 INLET TEMPERATURE	
CP-50DS00017	TCER	3#12, 1#12G	2155-PP-06	50-DS-00017	RP50DS00017					70-E-32	BLOWER ROOM SILENCER VALVE POWER	
CP-50CV00017	TCER	3#12, 1#12G	50-DS-00017	50-CV-00017	RP50CV00017					70-E-32	BLOWER ROOM SILENCER VALVE POWER	
CC-50CV00017	TCER	18#14, 1#14G	70-PLC-9000	50-CV-00017	RC50CV00017					70-E-32	BLOWER ROOM SILENCER VALVE CONTROLS	
CP-50DS00013	TCER	3#12, 1#12G	2155-PP-06	50-DS-00013	RP50DS00013					70-E-32	BLOWER 1 INLET VALVE POWER	
CP-50CV00013	TCER	3#12, 1#12G	50-DS-00013	50-CV-00013	RP50CV00013					70-E-32	BLOWER 1 INLET VALVE POWER	
CC-50CV00013	TCER	8#14, 1#14G	70-PLC-9000	50-CV-00013	RC50CV00013					70-E-32	BLOWER 1 INLET VALVE CONTROLS	
CS-50CV00013	INSM	2PR #18SH	70-PLC-9000	50-CV-00013	RS50CV00013					70-E-32	BLOWER 1 INLET VALVE SIGNAL	
CP-50DS00023	TCER	3#12, 1#12G	2155-PP-06	50-DS-00023	RP50DS00023					70-E-32	BLOWER 2 INLET VALVE POWER	
CP-50CV00023	TCER	3#12, 1#12G	50-DS-00023	50-CV-00023	RP50CV00023					70-E-32	BLOWER 2 INLET VALVE POWER	
CC-50CV00023	TCER	8#14, 1#14G	70-PLC-9000	50-CV-00023	RC50CV00023					70-E-32	BLOWER 2 INLET VALVE CONTROLS	
CS-50CV00023	INSM	2PR #18SH	70-PLC-9000	50-CV-00023	RS50CV00023					70-E-32	BLOWER 2 INLET VALVE SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CS-35FIT10011	INS	1PR #16SH	35-PLC-9000	35-FIT-10011	RS35FIT10011					35-E-11	FLOCCULATION BASIN 1 INLET FLOW	
CS-35FIT20011	INS	1PR #16SH	35-PLC-9000	35-FIT-20011	RS35FIT20011					35-E-11	FLOCCULATION BASIN 2 INLET FLOW	
CP-35P00010	XHHW2	3#12, 1#12G	35-DS-00010	35-P-00010	RP35P00010					35-E-10	RAW WATER SAMPLE PUMP POWER	
CP-35DS00010	TCER	3#12, 1#12G	MCC-2155	35-DS-00010	RP35DS00010					35-E-11	RAW WATER SAMPLE PUMP POWER	
CC-35LCS00010	TCER	11#14, 1#14G	35-PLC-9000	35-LCS-00010	RC35LCS00010					35-E-11	RAW WATER SAMPLE PUMP CONTROLS	
CP-35P00020	XHHW2	3#12, 1#12G	35-DS-00020	35-P-00020	RP35P00020					35-E-10	COAGULATED WATER SAMPLE PUMP POWER	
CP-35DS00020	TCER	3#12, 1#12G	MCC-2155	35-DS-00020	RP35DS00020					35-E-11	COAGULATED WATER SAMPLE PUMP POWER	
CC-35LCS00020	TCER	11#14, 1#14G	MCC-2155	35-LCS-00020	RC35LCS00020					35-E-11	COAGULATED WATER SAMPLE PUMP CONTROLS	
CC-35MCC2155E	TCER	11#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155E					35-E-11	COAGULATED WATER SAMPLE PUMP CONTROLS	
CC-35PSH00022	XHHW2	2#14, 1#14G	MCC-2155	35-PSH-00022	RC35PSH00022						COAGULATED WATER SAMPLE PUMP PRESSURE HIGH SWITCH	
CC-70LSLL00060	TCER	2#14, 1#14G	70-PLC-9000	70-LSLL-00060	RC70LSLL00060					35-E-04	CLEARWELL LOW-LOW LEVEL SWITCH	
CP-70LCS00040	TCER	2#12, 1#12G	2155-LP-03	70-LCS-00040	RP70LCS00040					35-E-04	CLEARWELL DRAIN PUMP 1 LCS POWER	
CP-70P00040	XHHW2	2#12, 1#12G	70-LCS-00040	70-P-00040	RP70P00040					35-E-04	CLEARWELL DRAIN PUMP 1 POWER	
CP-70LCS00050	TCER	2#12, 1#12G	2155-LP-03	70-LCS-00050	RP70LCS00050					35-E-04	CLEARWELL DRAIN PUMP 2 LCS POWER	
CP-70P00050	XHHW2	2#12, 1#12G	70-LCS-00050	70-P-00050	RP70P00050					35-E-04	CLEARWELL DRAIN PUMP 2 POWER	
CV-05LSH00007	VENDOR	Special	05-LCP-00015	05-LSH-00007	RC05LSH0007						INFILTRATION GALLERY LEVEL HIGH CONTROL	
CV-05LSM00007	VENDOR	Special	05-LCP-00015	05-LSH-00007	RC05LSH0007						INFILTRATION GALLERY LEVEL MEDIUM CONTROL	
CV-05LSL00007	VENDOR	Special	05-LCP-00015	05-LSH-00007	RC05LSH0007						INFILTRATION GALLERY LEVEL LOW CONTROL	
CV-05P00010	VENDOR	Special	05-LCP-00015	05-P-00010	RP05P00010						INFILTRATION GALLERY PUMP 1	
CV-05P00020	VENDOR	Special	05-LCP-00015	05-P-00020	RP05P00020						INFILTRATION GALLERY PUMP 2	
CC-05LCP00015	XHHW2	36#14, 1#14G	ACC2101	05-LCP-00015	RC05LCP00015						INFILTRATION GALLERY PUMP LCP CONTROLS	
CP-05LCP00015	XHHW2	3#12, 1#12G	MCC-2150	05-LCP-00015	RP05LCP00015						INFILTRATION GALLERY PUMP LCP POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CC-89LCS00010	XHHW2	8#14, 1#14G	MCC-2150	89-LCS-00010	RC89LCS00010						SODIUM HYPOCHLORITE TRANSFER PUMP LCP CONTROLS	
CC-01MCC2150C	XHHW2	8#14, 1#14G	ACC2101	MCC-2150	RC01MCC2150-C						SODIUM HYPOCHLORITE TRANSFER PUMP LCP CONTROLS	
CP-89DS00010	XHHW2	3#12, 1#12G	MCC-2150	89-DS-00010	RP89DS00010						SODIUM HYPOCHLORITE TRANSFER PUMP DISCONNECT POWER	
CP-89P00010	XHHW2	3#12, 1#12G	89-DS-00010	89-P-00010	RP89P00010						SODIUM HYPOCHLORITE TRANSFER PUMP POWER	
CS-89PIT00011	INS	1PR #16SH	ACC2101	89-PIT-00011	RS89PIT00011						SODIUM HYPOCHLORITE TRANSFER PRESSURE	
CS-89CV00012	XHHW2	18#14, 1#14G	ACC2101	89-CV-00012	RC89CV00012						SODIUM HYPOCHLORITE DAY TANK 1 CONTROL VALVE CONTROLS	
CP-89DS00012	XHHW2	3#12, 1#12G	LP2175	89-DS-00012	RP89DS00012						SODIUM HYPOCHLORITE DAY TANK 1 CONTROL VALVE DISCONNECT POWER	
CP-89CV00012	XHHW2	3#12, 1#12G	89-DS-00012	89-CV-00012	RP89CV00012						SODIUM HYPOCHLORITE DAY TANK 1 CONTROL VALVE POWER	
CS-89LIT00010	INS	1PR #16SH	ACC2101	89-LIT-00010	RS89LIT00010						SODIUM HYPOCHLORITE DAY TANK 1 LEVEL SIGNAL	
CP-89LIT00010	XHHW2	3#12, 1#12G	LP2175	89-LIT-00010	RP89LIT00010						SODIUM HYPOCHLORITE DAY TANK 1 LEVEL POWER	
CC-89 LSHH00010	XHHW2	2#14, 1#14G	ACC2101	89-LSHH-00010	RC89LSHH00010						SODIUM HYPOCHLORITE DAY TANK 1 HIGH LEVEL ALARM	
CC-89 LSLL00010	XHHW2	2#14, 1#14G	ACC2101	89-LSLL-00010	RC89LSLL00010						SODIUM HYPOCHLORITE DAY TANK 1 LOW LEVEL ALARM	
CC-89LCS-00020	XHHW2	8#14, 1#14G	MCC-2150	89-LCS-00020	RC89LCS00020						SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 LCS CONTROLS	
CC-01MCC2150D	XHHW2	8#14, 1#14G	ACC2101	MCC-2150	RC01MCC2150-D						SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 LCS CONTROLS	
CP-89DS00020	XHHW2	3#12, 1#12G	MCC-2150	89-DS-00020	RP89DS00020						SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 DISCONNECT POWER	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-89P00020	XHHW2	3#12, 1#12G	89-DS-00020	89-P-00020	RP89P00020						SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 POWER	
CS-89PIT00021	INS	1PR #16SH	ACC2101	89-PIT-00021	RS89PIT00021						SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 PRESSURE	
CS-89PIT00013	INS	1PR #16SH	ACC2101	89-PIT-00013	RS89PIT00013						SODIUM HYPOCHLORITE DAY TANK PRESSURE	
CC-89LC00030	XHHW2	8#14, 1#14G	89-LCS-00030	MCC-2150	RC89LCS00030						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 LCS CONTROLS	
CC-01MCC2150E	XHHW2	8#14, 1#14G	ACC2101	MCC-2150	RC01MCC2150-E						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 LCS CONTROLS	
CP-89DS00030	XHHW2	3#12, 1#12G	MCC-2150	89-DS-00030	RP89DS00030						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 DISCONNECT POWER	
CP-89P00030	XHHW2	3#12, 1#12G	89-DS-00030	89-P-00030	RP89P00030						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 POWER	
CS-89PI00031	INS	1PR #16SH	PIT00031	PI00031	RS89PI00031						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 PRESSURE	
CS-89PIT00031	INS	1PR #16SH	ACC2101	PIT00031	RS89PIT00031						SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 PRESSURE	
CC-89CV00022	XHHW2	18#14, 1#14G	ACC2101	CV00022	RC89CV00022						SODIUM HYPOCHLORITE DAY TANK 2 CONTROL VALVE CONTROLS	
CP-89DS00022	XHHW2	3#12, 1#12G	LP2175	89-DS-00022	RP89DS00022						SODIUM HYPOCHLORITE DAY TANK 2 CONTROL VALVE DISCONNECT POWER	
CP-89CV00022	XHHW2	3#12, 1#12G	89-DS-00022	89-CV-00022	RP89CV00022						SODIUM HYPOCHLORITE DAY TANK 2 CONTROL VALVE POWER	
CS-89LIT00020	INS	1PR #16SH	ACC2101	89-LIT-00020	RS89LIT00020						SODIUM HYPOCHLORITE DAY TANK 2 LEVEL SIGNAL	
CP-89LIT00020	XHHW2	3#12, 1#12G	LP2175	89-LIT-00020	RP89LIT00020						SODIUM HYPOCHLORITE DAY TANK 2 LEVEL POWER	
CC-89LSHH00020	XHHW2	2#14, 1#14G	ACC2101	89-LSHH-00020	RC89LSHH00020						SODIUM HYPOCHLORITE DAY TANK 2 HIGH LEVEL ALARM	

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CC-89LSLL00020	XHHW2	2#14, 1#14G	ACC2101	89-LSLL-00020	RC89LSLL00020						SODIUM HYPOCHLORITE DAY TANK 2 LOW LEVEL ALARM	
CC-89LCS00040	XHHW2	8#14, 1#14G	MCC-2150	89-LCS-00040	RC89LCS00040						SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 LCS CONTROLS	
CC-01MCC2150F	XHHW2	8#14, 1#14G	ACC2101	MCC-2150	RC01MCC2150-F						SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 LCS CONTROLS	
CP-89DS00040	XHHW2	3#12, 1#12G	MCC-2150	89-DS-00040	RP89DS00040						SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 DISCONNECT POWER	
CP-89P00040	XHHW2	3#12, 1#12G	89-DS-00040	89-P-00040	RP89P00040						SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 POWER	
CS-89PIT00041	INS	1PR #16SH	ACC2101	89-PIT-00041	RS89PIT00041						SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 PRESSURE	
CC-89LCS00050	XHHW2	8#14, 1#14G	MCC-2150	89-LCS-00050	RC89LCS00050						SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 LCS CONTROLS	
CC-01MCC2150	XHHW2	8#14, 1#14G	ACC2101	MCC-2150	RC89MCC2150-G						SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 LCS CONTROLS	
CP-89DS00050	XHHW2	3#12, 1#12G	MCC-2150	89-DS-00050	RP89DS00050						SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 DISCONNECT POWER	
CP-89P00050	XHHW2	3#12, 1#12G	89-DS-00050	89-P-00050	RP89P00050						SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 POWER	
CS-89PIT00051	INS	1PR #16SH	ACC2101	89-PIT-00051	RS89PIT00051						SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 PRESSURE	
CS-89PIT00023	INS	1PR #16SH	ACC2101	89-PIT-00023	RS89PIT00023						SODIUM HYPOCHLORITE DAY TANK 2 PRESSURE	
CS-01GEN2500	INS	1PR #16SH	ACC2101	GEN-2500	RS01GEN2500						GENERATOR FUEL LEVEL SIGNAL	
CC-01GEN2500	XHHW2	2#14, 1#14G	ACC2101	GEN-2500	RC01GEN2500						GENERATOR FAULT	
CC-01LSH2500	XHHW2	2#14, 1#14G	ACC2101	01-LSH-2500	RC01LSH2500						GENERATOR TO TANK PIPE LEVEL	
CC-01LSLL2500	XHHW2	2#14, 1#14G	ACC2101	01-LSLL-2500	RC01LSLL2500						GENERATOR TANK LOW LEVEL	
CS-01LIT2500	INS	1PR #16SH	ACC2101	01-LIT-2500	RS01LIT2500						GENERATOR TANK LEVEL	
CP-01 LIT2500	XHHW2	3#12, 1#12G	LP2175	01-LIT-2500	RP01LIT2500						GENERATOR TANK LEVEL POWER	

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CS-89P00080	INSM	2PR #18SH	ACC2101	89-P-00080	RS89P00080						SODIUM HYPOCHLORITE FEED PUMP 3 SIGNALS	
CC-89P00080	XHHW2	8#14, 1#14G	ACC2101	89-P-00080	RC89P00080						SODIUM HYPOCHLORITE FEED PUMP 3 CONTROLS	
CP-89DS00080	XHHW2	3#12, 1#12G	LP2175	89-DS-00080	RP89DS00080						SODIUM HYPOCHLORITE FEED PUMP 3 DISCONNECT POWER	
CP-89P00080	XHHW2	3#12, 1#12G	89-DS-00080	89-P-00080	RP89P00080						SODIUM HYPOCHLORITE FEED PUMP 3 POWER	
CS-89PIT00081	INS	1PR #16SH	ACC2101	89-PIT-00081	RS89PIT00081						SODIUM HYPOCHLORITE FEED PUMP 3 PRESSURE	
CS-89FIT00082	INS	1PR #16SH	ACC2101	89-FIT-00082	RS89FIT00082						SODIUM HYPOCHLORITE FEED PUMP 3 FLOW SIGNAL	
CP-89FIT00082	XHHW2	3#12, 1#12G	LP2175	89-FIT-00082	RP89FIT00082						SODIUM HYPOCHLORITE FEED PUMP 3 FLOW POWER	
CS-89P00060	INSM	2PR #18SH	ACC2101	89-P-00060	RS89P00060						SODIUM HYPOCHLORITE FEED PUMP 1 SIGNALS	
CC-89P00060	XHHW2	8#14, 1#14G	ACC2101	89-P-00060	RC89P00060						SODIUM HYPOCHLORITE FEED PUMP 1 CONTROLS	
CP-89DS00060	XHHW2	3#12, 1#12G	LP2175	89-DS-00060	RP89DS00060						SODIUM HYPOCHLORITE FEED PUMP 1 DISCONNECT POWER	
CP-89P00060	XHHW2	3#12, 1#12G	89-DS-00060	89-P-00060	RP89P00060						SODIUM HYPOCHLORITE FEED PUMP 1 POWER	
CS-89PIT00061	INS	1PR #16SH	ACC2101	89-PIT-00061	RS89PIT00061						SODIUM HYPOCHLORITE FEED PUMP 1 PRESSURE	
CS-89P00070	INSM	2PR #18SH	ACC2101	89-P-00070	RS89P00070						SODIUM HYPOCHLORITE FEED PUMP 2 SIGNALS	
CC-89P00070	XHHW2	8#14, 1#14G	ACC2101	89-P-00070	RC89P00070						SODIUM HYPOCHLORITE FEED PUMP 2 CONTROLS	
CP-89DS00070	XHHW2	3#12, 1#12G	LP2175	89-DS-00070	RP89DS00070						SODIUM HYPOCHLORITE FEED PUMP 2 DISCONNECT POWER	

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CP-89P00070	XHHW2	3#12, 1#12G	89-DS-00070	89-P-00070	RP89P00070						SODIUM HYPOCHLORITE FEED PUMP 2 POWER	
CS-89PIT00071	INS	1PR #16SH	ACC2101	89-PIT-00071	RS89PIT00071						SODIUM HYPOCHLORITE FEED PUMP 2 PRESSURE	
CS-89FIT00065	INS	1PR #16SH	ACC2101	89-FIT-00065	RS89FIT00065						SODIUM HYPOCHLORITE FEED PUMP 1 FLOW SIGNAL	
CP-89FIT00065	XHHW2	3#12, 1#12G	LP2175	89-FIT-00065	RP89FIT00065						SODIUM HYPOCHLORITE FEED PUMP 1 FLOW POWER	
CS-89P00110	INSM	2PR #18SH	ACC2101	89-P-00110	RS89P00110						SODIUM HYPOCHLORITE FEED PUMP 6 SIGNALS	
CC-89P00110	XHHW2	8#14, 1#14G	ACC2101	89-P-00110	RC89P00110						SODIUM HYPOCHLORITE FEED PUMP 6 CONTROLS	
CP-89DS00110	XHHW2	3#12, 1#12G	LP2175	89-DS-00110	RP89DS00110						SODIUM HYPOCHLORITE FEED PUMP 6 DISCONNECT POWER	
CP-89P00110	XHHW2	3#12, 1#12G	89-DS-00110	89-P-00110	RP89P00110						SODIUM HYPOCHLORITE FEED PUMP 6 POWER	
CS-89PIT00111	INS	1PR #16SH	ACC2101	89-PIT-00111	RS89PIT00111						SODIUM HYPOCHLORITE FEED PUMP 6 PRESSURE	
CS-89FIT00112	INS	1PR #16SH	ACC2101	89-FIT-00112	RS89FIT00112						SODIUM HYPOCHLORITE FEED PUMP 6 FLOW SIGNAL	
CP-89FIT00112	XHHW2	3#12, 1#12G	LP2175	89-FIT-00112	RP89FIT00112						SODIUM HYPOCHLORITE FEED PUMP 6 FLOW POWER	
CS-89P00100	INSM	2PR #18SH	ACC2101	89-P-00100	RS89P00100						SODIUM HYPOCHLORITE FEED PUMP 5 SIGNALS	
CC-89P00100	XHHW2	8#14, 1#14G	ACC2101	89-P-00100	RC89P00100						SODIUM HYPOCHLORITE FEED PUMP 5 CONTROLS	
CP-89DS00100	XHHW2	3#12, 1#12G	LP2175	89-DS-00100	RP89DS00100						SODIUM HYPOCHLORITE FEED PUMP 5 DISCONNECT POWER	
CP-89P00100	XHHW2	3#12, 1#12G	89-DS-00100	89-P-00100	RP89P00100						SODIUM HYPOCHLORITE FEED PUMP 5 POWER	

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CS-89PIT00101	INS	1PR #16SH	ACC2101	89-PIT-00101	RS89PIT00101						SODIUM HYPOCHLORITE FEED PUMP 5 PRESSURE	
CS-89P00090	INSM	2PR #18SH	ACC2101	89-P-00090	RS89P00090						SODIUM HYPOCHLORITE FEED PUMP 4 SIGNALS	
CC-89P00090	XHHW2	8#14, 1#14G	ACC2101	89-P-00090	RC89P00090						SODIUM HYPOCHLORITE FEED PUMP 4 CONTROLS	
CP-89DS00090	XHHW2	3#12, 1#12G	LP2175	89-DS-00090	RP89DS00090						SODIUM HYPOCHLORITE FEED PUMP 4 DISCONNECT POWER	
CP-89P00090	XHHW2	3#12, 1#12G	89-DS-000090	89-P-00090	RP89P00090						SODIUM HYPOCHLORITE FEED PUMP 4 POWER	
CS-89PIT00091	INS	1PR #16SH	ACC2101	89-PIT-00091	RS89PIT00091						SODIUM HYPOCHLORITE FEED PUMP 4 PRESSURE	
CS-89FIT00095	INS	1PR #16SH	ACC2101	89-FIT-00095	RS89FIT00095						SODIUM HYPOCHLORITE FEED PUMP 4 FLOW SIGNAL	
CP-89FIT00095	XHHW2	3#12, 1#12G	LP2175	89-FIT-00095	RP89FIT00095						SODIUM HYPOCHLORITE FEED PUMP 4 FLOW POWER	
CS-35FIT00012	INS	1PR #16SH	35-PLC-9000	35-FIT-00012	RS35FIT00012						INFILTRATION GALLERY PS EFFULENT FLOW SIGNAL	
CS-35FE00012	INS	1PR #16SH	35-FIT-00012	35-FE-00012	RS35FE00012						INFILTRATION GALLERY PS EFFULENT FLOW SIGNAL	
CP-35FIT00012	XHHW2	2#12, 1#12G	2155-LP-01	35-FIT-00012	RP35FIT00012						INFILTRATION GALLERY PS EFFULENT FLOW POWER	
CS-35FIT00011	INS	1PR #16SH	35-PLC-9000	35-FIT-00012	RS35FIT00012						CLARIFIER EFFLUENT FLOW SIGNAL	
CS-35FE00011	INS	1PR #16SH	35-FIT-00012	35-FE-00012	RS35FE00012						CLARIFIER EFFLUENT FLOW SIGNAL	
CP-35FIT00011	XHHW2	2#12, 1#12G	2155-LP-01	35-FIT-00012	RP35FIT00012						CLARIFIER EFFLUENT FLOW POWER	
CC-20PSH0001A	XHHW2	2#14, 1#14G	35-PLC-9000	20-PSH-0001A	RC20PSH0001A						FLASH MIX SYSTEM PRESSURE	
CC-20PSH00012	XHHW2	4#14, 1#14G	MCC-2155	20-PSH-00012	RC20PSH00012						FLASH MIX PUMP 2 INLETT PRESSURE	
CC-20LCP20010	XHHW2	8#14, 1#14G	MCC-2155	20-LCP-20010	RC20LCP20010						FLASH MIX PUMP 2 LCP CONTROLS	
CC-20P20010	XHHW2	2#14, 1#14G	MCC-2155	20-P-20010	RC20P20010						FLASH MIX PUMP 2 CONTROL	

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CC-35MCC2155C	XHHW2	18#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155C						FLASH MIX PUMP 2 CONTROLS	
CS-35MCC2155A	INSM	2PR #16SH	35-PLC-9000	MCC-2155	RS35MCC2155A						FLASH MIX PUMP 2 SPEEDS CONTROL	
CC-35MCC2155D	XHHW2	18#14, 1#14G	35-PLC-9000	MCC-2155	RC35MCC2155D						FLASH MIX PUMP 1 CONTROL	
CS-35MCC2155B	INSM	2PR #16SH	35-PLC-9000	MCC-2155	RS35MCC2155B						FLASH MIX PUMP 1 SPEEDS CONTROL	
CC-20LCP10010	XHHW2	8#14, 1#14G	MCC-2155	20-LCP-10010	RC20LCP10010						FLASH MIX PUMP 1 LCP CONTROLS	
CC-20P10010	XHHW2	4#14, 1#14G	MCC-2155	20-P-10010	RC20P10010						FLASH MIX PUMP 2 CONTROL	
CC-20PSH00013	XHHW2	4#14, 1#14G	MCC-2155	20-PSH-00013	RC20PSH00013						FLASH MIX PUMP 1 PRESSURE	
CC-20LSH10011	XHHW2	2#14, 1#14G	35-PLC-9000	20-LSH-10011	RC20LSH10011						FLASH MIX PUMP 1 HIGH LEVEL	
CC-20SV10012	XHHW2	2#14, 1#14G	35-PLC-9000	20-SV-10012	RC20SV10012						FLASH MIX PUMP 1 SOLINOID VALVE	
CC-20LSH20011	XHHW2	2#14, 1#14G	35-PLC-9000	20-LSH-20011	RC20LSH20011						FLASH MIX PUMP 2 HIGH LEVEL	
CC-20SV20012	XHHW2	2#14, 1#14G	35-PLC-9000	20-SV-20012	RC20SV20012						FLASH MIX PUMP 2 SOLINOID VALVE	
CC-20SV10011	XHHW2	2#14, 1#14G	35-PLC-9000	20-SV-10011	RC20SV10011						FLASH MIX PUMP 1 SOLINOID VALVE	
CC-20SV20011	XHHW2	2#14, 1#14G	35-PLC-9000	20-SV-20011	RC20SV20011						FLASH MIX PUMP 2 SOLINOID VALVE	
CC-35MCC2155F	XHHW2	2#14, 1#14G	MCC-2155	MCC-2155							35-VFD-10010 TO 35-VFD-20010	
CP-20FIT00020	XHHW2	2#12, 1#12G	2155-LP-01	20-FIT-00020	RP20FIT00020						FLASH MIX INJECTION FLOW POWER	
CC-20FIT00020	XHHW2	2#14, 1#14G	35-PLC-9000	20-FIT-00020	RC20FIT00020						FLASH MIX INJECTION FLOW CONTROL	
CS-20FIT00020	INS	1PR #16SH	35-PLC-9000	20-FIT-00020	RS20FIT00020						FLASH MIX INJECTION FLOW SIGNAL	
CS-30FIT10011	INS	1PR #16SH	35-PLC-9000	30-FIT-10011	RS30FIT10011						FLOC BASIN 1 INLET CHANNEL FLOW SIGNAL	
CS-30FE10011	INS	1PR #16SH	30-FIT-10011	30-FE-10011	RS30FE10011						FLOC BASIN 1 INLET CHANNEL FLOW SIGNAL	
CP-30FIT10011	XHHW2	2#12, 1#12G	2155-LP-01	30-FIT-10011	RP30FIT10011						FLOC BASIN 1 INLET CHANNEL FLOW POWER	
CC-30CV10011	XHHW2	10#14, 1#14G	35-PLC-9000	30-CV-10011	RC30CV10011						FLOCULATION BASIN 1 INLET VALVE CONTROL	
CS-30CV10011	INSM	2PR #16SH	35-PLC-9000	30-CV-10011	RS30CV10011						FLOCULATION BASIN 1 INLET VALVE SIGNAL	
CV-30CS10011	VENDOR	Special	30-CV-10011	30-CS-10011	RV30CS10011						FLOCULATION BASIN 1 INLET VALVE CONTROL	
CP-30DS10011	XHHW2	3#12, 1#12G	2155-PP-03	30-DS-10011	RP30DS10011						FLOCULATION BASIN 1 INLET VALVE DISCONNECT POWER	
CP-30CV10011	XHHW2	3#12, 1#12G	30-DS-10011	30-CV-10011	RP30CV10011						FLOCULATION BASIN 1 INLET VALVE POWER	
CS-30FIT20011	INS	1PR #16SH	35-PLC-9000	30-FIT-20011	RS30FIT20011						FLOC BASIN 2 INLET CHANNEL FLOW SIGNAL	
CS-30FE20011	INS	1PR #16SH	30-FIT-10011	30-FE-20011	RS30FE20011						FLOC BASIN 2 INLET CHANNEL FLOW SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA				PLAN DRAWING	COMMENTS	CONTRACT / REV
CP-30FIT20011	XHHW2	2#12, 1#12G	2155-LP-01	30-FIT-20011	RP30FIT20011					FLOC BASIN 2 INLET CHANNEL FLOW POWER	
CC-30CV20011	XHHW2	10#14, 1#14G	35-PLC-9000	30-CV-20011	RC30CV20011					FLOCULATION BASIN 2 INLET VALVE CONTROL	
CS-30CV20011	INSM	2PR #16SH	35-PLC-9000	30-CV-20011	RS30CV20011					FLOCULATION BASIN 2 INLET VALVE SIGNAL	
CV-30CS20011	VENDOR	Special	30-CV-10011	30-CS-20011	RV30CS20011					FLOCULATION BASIN 2 INLET VALVE CONTROL	
CP-30DS20011	XHHW2	3#12, 1#12G	2155-PP-03	30-DS-20011	RP30DS20011					FLOCULATION BASIN 2 INLET VALVE DISCONNECT POWER	
CP-30CV20011	XHHW2	3#12, 1#12G	30-DS-10011	30-CV-20011	RP30CV20011					FLOCULATION BASIN 2 INLET VALVE POWER	
CS-35AIT00023	INS	1PR #16SH	35-PLC-9000	35-AIT-00023	RS35AIT00023					FLASH MIX COAGULATED SAMPLE SC	
CV-35AE00023	INS	1PR #16SH	35-AIT-00023	35-AE-00023	RS35AE00023					FLASH MIX COAGULATED SAMPLE SC	
CP-35AIT00023	XHHW2	2#12, 1#12G	2155-LP-01	35-AIT-00023	RP35AIT00023					FLASH MIX COAGULATED SAMPLE SC POWER	
CS-40AIT10004	INS	1PR #16SH	35-PLC-9000	40-AIT-10004	RS40AIT10004					SEDIMENTATION BASIN 1A TURB SIGNAL	
CV-40AE10004	INS	1PR #16SH	40-AIT-10004	40-AE-10004	RS40AE10004					SEDIMENTATION BASIN 1A TURB SIGNAL	
CP-40AIT10004	XHHW2	2#12, 1#12G	2155-LP-01	40-AIT-10004	RP40AIT10004					SEDIMENTATION BASIN 1A TURB POWER	
CP-40DS10012	XHHW2	3#12, 1#12G	2155-PP-01	40-DS-10012	RP40DS10012					SED BASIN 1 BACKFILL VALVE DISCONNECT POWER	
CP-40CV10012	XHHW2	3#12, 1#12G	40-DS-10012	40-CV-10012	RP40CV10012					SED BASIN 1 BACKFILL VALVE POWER	
CS-40CV10012	INSM	2PR #16SH	35-PLC-9000	40-CV-10012	RS40CV10012					SED BASIN 1 BACKFILL VALVE SIGNAL	
CC-40CV10012	XHHW2	10#14, 1#14G	35-PLC-9000	40-CV-10012	RC40CV10012					SED BASIN 1 BACKFILL VALVE CONTROL	
CS-40AIT20004	INS	1PR #16SH	35-PLC-9000	40-AIT-20004	RS40AIT20004					SEDIMENTATION BASIN 2A TURB SIGNAL	
CV-40AE20004	INS	1PR #16SH	40-AIT-20004	40-AE-20004	RS40AE20004					SEDIMENTATION BASIN 2A TURB SIGNAL	
CP-40AIT20004	TCER	2#12, 1#12G	2155-LP-01	40-AIT-20004	RP40AIT20004					SEDIMENTATION BASIN 2A TURB POWER	
CP-40DS20012	XHHW2	3#12, 1#12G	2155-PP-02	40-DS-20012	RP40DS20012					SED BASIN 2 BACKFILL VALVE DISCONNECT POWER	
CP-40CV20012	XHHW2	3#12, 1#12G	40-DS-20012	40-CV-20012	RP40CV20012					SED BASIN 2 BACKFILL VALVE POWER	
CS-40CV20012	INSM	2PR #16SH	35-PLC-9000	40-CV-20012	RS40CV20012					SED BASIN 2 BACKFILL VALVE SIGNAL	
CC-40CV20012	XHHW2	10#14, 1#14G	35-PLC-9000	40-CV-20012	RC40CV20012					SED BASIN 2 BACKFILL VALVE CONTROL	
CP-50AIT10131	XHHW2	2#12, 1#12G	2155-LP-01	50-AIT-10131	RP50AIT10131					FILTER 1 TURB / PARTICLE COUNT DEDICATED RECEPTACLE	
CS-50AIT10131	INS	1PR #16SH	35-PLC-9001	50-AIT-10131	RS50AIT10131					FILTER 1 TURB SIGNAL	

CABLE TAG	TYPE	CONDUCTORS	CABLE FROM	CABLE TO	VIA					PLAN DRAWING	COMMENTS	CONTRACT / REV
CV-50AE10131	INS	1PR #16SH	50-AIT-10131	50-AE-10131	RS50AE10131						FILTER 1 TURB SIGNAL	
CS-50AIT10141	INS	1PR #16SH	35-PLC-9001	50-AIT-10141	RS50AIT10141						FILTER 1 PARTICLE COUNT SIGNAL	
CP-50FIT10010	XHHW2	2#12, 1#12G	2155-LP-01	50-FIT-10010	RP50FIT10010						FILTER 1 COMBINED FILTER WATER FLOW POWER	
CS-50FIT10010	INS	1PR #16SH	35-PLC-9001	50-FIT-10010	RS50FIT10010						FILTER 1 COMBINED FILTER WATER FLOW SIGNAL	
CP-50AIT20131	XHHW2	2#12, 1#12G	2155-LP-01	50-AIT-20131	RP50AIT20131						FILTER 2 TURB / PARTICLE COUNT DEDICATED RECEPTACLE	
CS-50AIT20131	INS	1PR #16SH	35-PLC-9002	50-AIT-20131	RS50AIT20131						FILTER 2 TURB SIGNAL	
CV-50AE20131	INS	1PR #16SH	50-AIT-20131	50-AE-20131	RS50AE20131						FILTER 2 TURB SIGNAL	
CS-50AIT20141	INS	1PR #16SH	35-PLC-9002	50-AIT-20141	RS50AIT20141						FILTER 2 PARTICLE COUNT SIGNAL	
CP-50FIT20010	XHHW2	2#12, 1#12G	2155-LP-01	50-FIT-20010	RP50FIT20010						FILTER 2 COMBINED FILTER WATER FLOW POWER	
CS-50FIT20010	INS	1PR #16SH	35-PLC-9001	50-FIT-20010	RS50FIT20010						FILTER 2 COMBINED FILTER WATER FLOW SIGNAL	
CP-20DS10010	VFD1	3#12, 1#12G	MCC-2155	20-DS-10010	RP20DS10010					35-E-12	FLASH MIX PUMP 1	
CP-20P10010	VFD1	3#12, 1#12G	20-DS-10010	20-P-10010	RP20P10010						FLASH MIX PUMP 1	

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. The electrical equipment and conductors to be tested are specified herein and shown on the electrical drawings of the Contract Documents.
2. The Contractor shall retain an independent InterNational Electrical Testing Association (NETA) member Engineering and Testing Firm (Testing Firm) for specified on-site acceptance testing of the project electrical power distribution system and utilization equipment covered by this contract.
3. The Testing Firm shall be responsible for the Short Circuit and Protective Device Coordination Report as specified in Section 26 05 74. The Testing Firm shall verify the protective device settings are implemented in accordance with Section 26 05 74. The Testing Firm work includes the ARC-Fault equipment labeling work as specified in Section 26 05 74.
4. Tests performed by the Testing Firm shall be witnessed by the Owner's Representative. Provide the Construction Manager 30-day advanced notice for Testing Firm tests. Insulation tests by the Contractor typically will not be witnessed. Critical equipment witness testing may be requested by the Construction Manager.
5. The manufacturer of the electrical equipment supplied for the project shall complete their on-site factory inspection, testing, and setup prior to the Testing Firm's Acceptance Testing and subsequent Protective Device setting verification work. The power monitors shall be set up by the factory representatives and power monitor readings and settings verified by the Testing Firm. Manufacturer work is specified in the respective equipment sections.
6. The Installation Contractor shall test motors, conductors, and equipment as specified and shown. Contractor shall provide the labor, tools, material, including quality power sources required by the Testing Firm equipment, and other services necessary to provide specified tests and retesting.
7. Submit proposed electrical test procedures for tests to be performed by the Installing Contractor, other than insulation resistance testing, and proposed test procedures for tests to be performed by the Testing Firm.

1.02 QUALITY ASSURANCE

A. References

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/NETA ATS	International Electrical Testing Association (NETA) - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

B. Testing Firm:
   1. The Testing Firm and their proposed project team shall possess the following minimum qualifications:
      a. Testing Firm shall be an independent testing organization providing unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems to be evaluated.
      b. Testing Firm shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems.
      c. Testing Firm shall be a “NETA Accredited Company” of the InterNational Electrical Testing Association (NETA providing testing in accordance with ANSI/NETA ATS published specifications or the pre-approved firms that use the NETA methods and published testing specifications.
      d. If firm's own published testing specifications are proposed, then submit a copy to the Engineer for acceptance and submit the qualifications of the testing staff.
      e. Testing Firm's lead technical person shall be currently certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution systems testing. Submit proof of technical training and certification for performing testing work.
      f. Testing Firm's technicians shall be regularly employed, qualified testing staff.
      g. The following are pre-qualified Testing Firms:
         1) Emerson Electrical Reliability Services
         2) Power Systems Testing Co.

C. Testing Firm Qualifications:
   1. For any Testing Firm not pre-qualified, the Contractor shall receive Construction Manager approval of the proposed Testing Firm, their proposed project team, and their test procedures prior to the Pre-Test Submittals.
      a. Project Team:
         1) Identify lead technical person and testing staff and provide documentation of training and experience demonstrating compliance with the qualifications specified.

b. Testing Firm:
   1) Provide reference names and current phone numbers of the Owner, Contractor, Engineer, or Construction Manager that has knowledge of the Firm's work:
      a) Three projects for Owner completed within the past four years, or
      b) Three projects for Brown and Caldwell completed within the past four years, or
      c) Provide references for five recent projects that were completed within the last four years. Provide a description of the scope of the referenced project.

c. For Testing Firm's experience to be judged acceptable, the Contractor shall demonstrate that the proposed Testing Firm's reference projects are of similar scope and size to this project, and in performing these projects the following has been achieved:
   1) Testing Firm's work did not delay the projects or adversely impact the progress of the Contractor's work or the Owner's project.
   2) Specified requirements were achieved.
   3) Work was performed in accordance with ANSI/NETA ATS, MTS, or other Engineer accepted testing criteria.
   4) Submittals approved with two or fewer re-submittals after the initial submittal.
   5) No warranty claims related to the Testing Firm's work.

d. Provide documentation demonstrating NETA Accreditation and compliance with the qualification specified.

1.03 SUBMITTALS

A. Contractor shall submit the following information in accordance with specification Section 01 33 00:

B. Testing Firm Qualifications:
   1. For any Testing Firm not pre-qualified per paragraph 1.02 Testing Form, submit qualifications per paragraph 1.02 Testing Firm Qualifications.

C. Pre-Test Submittals:
   1. Description or samples of specified test procedures.
   2. Sample test report forms for the specified tests.
   3. Preliminary Schedule listing equipment to be tested.
   4. Notification form for the work scheduled.
   5. Pre-Functional test procedures and testing schedule.
   6. Functional test procedures and testing schedule.

Form No.	Title
26 05 00-A	Wire and Cable Resistance Test Data Form
26 05 00-B	Installed Motor Test Data Form
26 05 00-C	Dry Transformer Test Data Form
26 05 00-D	Motor Control Center Test Form

Form No.	Title
26 05 00-E	Medium Voltage Motor Starter Test Form
26 05 00-F	Medium Voltage Switchgear Test Form
26 05 00-G	Protective Relay Test Form
26 05 00-H	Low Voltage Switchgear Test Form
26 05 00-I	Medium Voltage Load Interrupter Switch Test Form
26 05 00-J	Liquid-Filled Transformer Test Form
26 05 00-K	Automatic Transfer Switch Test Form
26 05 00-L	Neutral Grounding Resistor Test
40 61 13-A	Loop Wiring and Insulation Resistance Test Data Form
40 61 13-B	Control Circuit Piping Leak Test Form
40 61 13-C	Controller Calibration Test Data Form
40 61 13-D	Panel Indicator Calibration Test Data Form
40 61 13-E	Recorder Calibration Test Data Form
40 61 13-F	Signal Trip Calibration Test Data Form
40 61 13-G	Field Switch Calibration Test Data Form
40 61 13-H	Transmitter Calibration Test Data Form
40 61 13-I	Miscellaneous Instrument Calibration Test Data Form
40 61 13-J	Individual Loop Test Data Form
40 61 13-K	Loop Commissioning Test Data Form

D. Post-Test Submittals:
   1. Completed Section 01 99 90 Test Records:
      a. Wire and Cable Resistance Test Data Form: 26 05 00-A
      b. Installed Motor Test Form: 26 05 00-B
      c. [Dry Transformer Test Data Form: 26 05 00-C]
      d. [ ]
   2. Test Reports specified in Part 3 of this Section.

PART 2 PRODUCTS

2.01 TESTING EQUIPMENT AND INSTRUMENTS

A. The test equipment, instruments and devices used for testing shall be calibrated to test equipment standards with references traceable to the National Institute of Standards and Technology.

B. The test equipment, instruments and devices shall have current calibration stickers indicating date of calibration, deviation from standard, name of calibration laboratory and technician, and date of next recalibration.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall submit a schedule for the Testing Firm work and notify the Construction Manager 30 days prior to commencement of any witnessed testing.

B. The required tests, including correction of defects where found, and subsequent retesting, shall be completed prior to energizing electrical distribution system, utilization systems, and conductors and completed prior to functional testing. The installation of the protective device, breaker, and relay settings shall be completed and verified.

3.02 INSTALLATION CONTRACTOR TESTING

A. General:
   1. Submit all completed test report forms in a 3-ring binder type notebook at the project Substantial Completion date.

B. Insulation Resistance Measurements:
   1. Tests:
      a. Insulation resistance measurements shall be made on conductors and electrical equipment that will carry current. Where not specified, the minimum acceptable values of insulation resistance shall be in accordance with the applicable NETA-ATS, ICEA, NEMA, or ANSI standards for the equipment or material being tested.
   2. The ambient temperature at which insulation resistance is measured shall be recorded on the test form. A megohmmeter shall be used for insulation resistance measurements.
   3. Refer to specification Section 01 99 90 for the test forms required to document the testing performed by the Installing Contractor.
   4. Conductor and Cable Tests:
      a. The phase-to-ground insulation resistance shall be measured for circuits 120 volts and above except lighting circuits. Measurements may be made with motors and other load equipment connected. Insulation resistance measurements shall be recorded on Form 26 05 00-A contained in Section 01 99 90, and submitted. Insulation with resistance of less than 100 megohms is not acceptable.
   5. Motor Tests:
      a. The Installed Motor Test Form, Form 26 05 00-B, contained in Section 01 99 90, shall be completed for each motor after installation and submitted. All motors shall have their insulation resistance measured before they are connected.
   6. Motors 50 HP and larger shall have their insulation resistance measured at the time of delivery and when they are connected. Insulation resistance values less than 50 megohms are not acceptable.
   7. Verify that motors are connected to rotate in the correct direction with the load disconnected. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation.
   8. Motor running current shall be measured on each phase with the motor operating under load. Current imbalance shall be less than 5-percent difference between phases.

C. Power Distribution Equipment:
   1. Transformers, panelboards, and other power distribution equipment shall have their insulation resistance measured phase-to-phase and phase-to-ground. Insulation resistance values less than 10 megohms are not acceptable.

D. Power Utilization Equipment:
   1. Test receptacles and power outlets using a device to verify polarity, grounding, and the correct wiring connections.

E. Signal and Data Cable Tests:
   1. Signal conductors and shield drain shall be tested for insulation resistance with the other conductors in the cable grounded. Each shield drain conductor shall be tested for continuity. Insulation resistance measurements shall be recorded on Form 40 61 13-A contained in Section 01 99 90, and submitted.
   2. Instruments used for continuity measurements shall have a resolution of 0.1 ohms and an accuracy of better than 0.1 percent of reading plus 0.3 ohms. A 500-volt or 1000-volt meg-ohmmeter shall be used for insulation resistance measurements as appropriate.

F. Pre-Functional Checkout:
   1. Prior to energizing equipment, the Contractor shall perform a pre-functional checkout of the power and the control circuit. Protective devices shall be installed and available for service and calibrated or adjusted with specified setpoints installed. Contractor selected initial setpoints shall be installed and recorded, when specified setpoints are not required from the manufacturer or the Engineer.
   2. Contractor shall submit a description of proposed test and checkout procedures conforming to the following requirements, including a schedule for conducting these procedures, not less than 30 days prior to the performance of pre-functional testing.
   3. Pre-functional checkout shall consist of energizing each control circuit and operating each control device, protective device, monitoring or alarm device, and each interlock and verify the specified action or response occurs. Coordinate testing with the requirements specified in Section 01 45 20.

G. Functional Testing:
   1. Contractor shall submit a description of proposed functional test and checkout procedures conforming to the following requirements, including a schedule for conducting these procedures, not less than 30 days prior to the performance of functional testing.
   2. Prior to functional testing, all protective devices shall be adjusted and made operative. Prior to energization of associated equipment, perform a functional checkout of all electrical and instrumentation control circuits as specified in the following and in Division 40. Checkout shall consist of energizing each control circuit and operating each control, alarm, safety device, and each interlock, in turn, to verify that the specified action occurs.
   3. Record and submit data sheets as specified. Coordinate testing with the requirements specified in Section 01 45 20.

3.03 TESTING FIRM ACCEPTANCE TESTING REQUIREMENTS

A. Acceptance Test Reports:
   1. The Contractor shall maintain a written record of all inspection and test results and, upon completion of the project, shall assemble and certify a final test report
   2. A copy of the preliminary test results shall be provided to the Construction Manager at the end of each day of testing.

3. Furnish two copies of the complete acceptance testing final report to the Construction Manager at Substantial Completion of the project.

B. Acceptance Test Documentation: The Contractor shall submit test documentation forms and a detailed description of the proposed inspection and test procedures to be performed by the Testing Firm. Testing shall not commence until the Construction Manager has approved the proposed forms and procedures.

C. The description shall identify the test equipment required for each specified test to be performed. Test report forms shall include the following information:
   1. Electrical equipment description.
   2. Electrical equipment identification number.
   3. Electrical equipment nameplate data.
   4. Electrical equipment settings.
   5. Time and date of test.
   6. Ambient conditions at time of test.
   7. Inspection checklist and results.
   8. Test results.
   9. Test equipment used with manufacture, model number, and calibration date.
   10. Remarks about test procedures, results, and suggestions.
   11. Name and signature of testing personnel.
   12. Name and signature of test witness.

D. Acceptance Testing Firm Tests:
   1. Acceptance testing procedures and test results shall be as specified in ANSI/NETA ATS. The following types of equipment and systems shall be inspected and tested by the Testing Firm. Acceptance testing work shall not be limited to equipment shown on the drawings. Refer to Division 26 specification for the electrical equipment specified.
      a. Refer to the electrical drawings for location and identification of the electrical distribution system equipment, utilization equipment, and electrical conductors, included but not limited to:
         1) Switchgear and Switchboard Assemblies.
         2) Transformers Dry-Type Air-Cooled.
         3) Transformers Liquid Filled.
         4) Cables Low-Voltage 600 Volt Maximum.
         5) Circuit Breakers Low-Voltage, 100A frame and larger.
         6) Protective Relays.
         7) Instrument Transformers.
         8) Metering, include non-utility power metering equipment.
         9) Grounding Systems include installed grounding systems and existing grounding systems that are being utilized.
         10) Ground Fault Protection Systems.
         11) Motors.
         12) Motor Starters Low-Voltage.

13) Motor Control Centers Low-Voltage.
14) Adjustable Speed Drive Systems and harmonic testing per Section 26 29 23-3.02.
15) Surge Protection Devices, include lightning arresters, surge capacitors, and TVSS.
16) Engine Generators.
17) Automatic Transfer Switches (ATS).
18) Manual Transfer Switched (MTS).

3.04 ACCEPTANCE TEST VALUES

A. Minimum acceptable test values shall be as specified in ANSI/NETA ATS. Where acceptance test values are not specified, the equipment manufacturer's recommended test values shall be used. Where acceptance test values are not specified and the equipment manufacturers recommended test values are not available, request acceptance test values from the Construction Manager.

3.05 ACCEPTANCE TEST FINAL REPORT

A. Test report shall be assembled as described in ANSI/NETA ATS. Test results shall be organized by electrical distribution system equipment, project utilization equipment, and electrical conductors with individual tab dividers with labels to identify each group of items and cross-referenced to the Contract Documents. The equipment description, equipment number, and equipment tag number shall be used as shown on the drawings or listed in specifications.

B. Final Test Reports that are illogically assembled, labeled, and organized shall be returned for rework at no cost to the Owner and resubmitted in an acceptable format.

C. Deficiencies and non-compliant test results found during acceptance testing shall be identified in the test report and cover letter. The Testing Firm shall certify in the final test report that all deficiencies and non-compliant test results listed have been "corrected" and shall include a description of the resolution for each problem listed.

3.06 PROTECTIVE DEVICE FIELD SETTINGS

A. The Testing Firm shall verify, and certify in the acceptance test final report, that the protective device coordination study settings for new and existing equipment based on the Short Circuit and Protective Device Coordination Report specified in Section 26 05 74 have been implemented and recorded on the Testing Firm's Data Sheets.

3.07 ARC FLASH STUDY RESULTS

A. The Testing Firm shall provide and install labels on the project electrical equipment for personnel protective clothing requirements as specified in Section 26 05 74.

END OF SECTION

SECTION 26 09 13

ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies power monitors and associated instrument transformers, test switches, fuses and accessories for electrical distribution equipment assemblies.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE 519	Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
IEC 61850	Power Utility Automation
IEEE C57.13	Standard Requirements for Instrument Transformers
IEC 61557-12	Electrical safety in low voltage distribution systems up to 1000V a.c. and 1500V d.c. – Equipment for testing, measuring, or monitoring of protective measures – Part 12: Power metering and monitoring devices (PMD)."
ANSI C12.20	Electricity Meters – 0.1, 0.2 and 0.5 Accuracy Classes
IEC 62053-22	Electricity Metering Equipment – Static Meters for Active Energy

1.03 SUBMITTALS

The following information shall be provided in accordance with Section 01 33 00:

1. Catalog and technical data including outline dimensions and weights.
2. Elementary connection and interconnection diagrams..

PART 2 PRODUCTS

2.01 INSTRUMENT TRANSFORMERS

A. General:
   1. Instrument transformers shall be molded dry-type in accordance with ANSI C57.13. Transformer volt-ampere rating shall be suitable for carrying the specified load without overheating or exceeding the permissible accuracy for the transformer.

B. Potential Transformers:
   1. Potential transformers shall have an ANSI accuracy class of 0.3. They shall be equipped with current limiting fuses.

C. Current Transformers:
   1. Current transformers shall be furnished with the specified ratios. The accuracies shall conform to IEEE C37.20.1.

2.02 POWER AND POWER QUALITY METERS

A. Provide Power Meters, Power Quality Meters, or Advanced Power Quality Meters as shown on the drawings and as described herein.

B. Provide a separate metering compartment with front hinged door as needed. Include associated instrument transformers. Mount monitoring device on the compartment door to allow operator access to meter menu and display. No wiring above 120 V maximum, shall be extended to the unit at the door.

C. Provide current transformers (CT) for each meter as required. Current transformers shall be wired to shorting-type terminal blocks before connecting to any other device. Current transformers shall be suitable for carrying the rated current at the specified thermal rating factor without overheating or exceeding the permissible accuracy at load level currents.

D. Potential transformers (PT) including primary and secondary fuses with disconnecting means shall be provided for metering as shown on the drawings.

   1. Potential transformers shall have an ANSI accuracy class of 0.3 with a burden determined by the manufacturer.
   2. Unless otherwise specified, potential transformers wired 480-120 V shall consist of three (3) PTs with secondary connected in WYE (120 V phase to neutral).
   3. Potential transformer volt-ampere rating shall be suitable for carrying the specified load without overheating or exceeding the permissible accuracy for the transformer.

E. Setup for system requirements shall be from power meter display and shall include: CT rating, PT rating, and system type. Ratios shall be programmable; DIP switches or other fixed ratios shall not be acceptable.

F. Include voltage and current test block and plug.

2.03 POWER METERS

A. Provide one of the following specified product and manufacturer : PowerLogic PM 5000 Series by Schneider Electric, Electro Industries Shark 200 Series, or Eaton Power Xpert 1000 Series.

B. The metering device used to monitor circuits for purposes of network management, energy cost management, energy allocation, and operational efficiency shall provide the following minimum features:

1. Connections and form factor - direct connect to circuits up to 600 VAC, eliminating the need for voltage (potential) transformers; 5 A nominal current inputs. Removable connectors for voltage inputs, control power, communications, inputs and outputs; easily mountable in the pre-made cutout without tools; form factor will be ¼ DIN with 92 X 92 cut-out and 96 x 96 panel mount integrated display.
2. Supported monitoring parameters—full range of 3-phase voltage, measure each phase and neutral current using 4 current inputs, power and energy measurements, power factor, frequency, total harmonic distortion (THD), individual power harmonics (up to 63rd order).
3. Accuracy shall comply with ANSI C12.20 class 0.2 and IEC 62053-22 class 0.2S for revenue meters.
4. Support 4 digital inputs for Demand Synch Pulse, Time Synch Input, and Conditional Energy Control; have 2 digital outputs that operate either by user command sent over communication link, or in response to a user defined alarm or event.
5. Communications - serial RS-485 Modbus, Ethernet Modbus TCP, Ethernet BACnet IP (BTL listed), and EtherNet IP; provide 2 Ethernet ports to allow wiring from meter to meter as a daisy-chain; be capable of serving data over the Ethernet network accessible through a standard web browser; the monitor shall contain default pages from the factory.
6. Onboard data logging capabilities - to log data, alarms and events; logged information shall include data logs, minimum/maximum log files of selected parameter values, and alarm logs for each user defined alarm or event log; support the following on-board nonvolatile memory—14 parameters every 15 minutes for 90 days.
7. Alarming capabilities - support 29 set-point driven alarms, 4 digital alarms, 4 unary alarms, 10 Boolean alarms and 5 custom alarms; user definable alarm events; set-point driven alarms shall be available for voltage/current parameters, input status, and end of interval status; shall send emails and/or text messages containing alarm condition indication via Simple Mail Transfer Protocol [SMTP]; Shall have the capability to manage and monitor devices on the IP network via Simple Network Management Protocol [SNMP]; Indication of an alarm condition shall be delivered by SNMP Traps.
8. Firmware-upgradeable to enhance functionality through the Ethernet or serial communication connection and shall allow upgrades of individual meters or groups.
9. Integrated gateway functionality, enabling the capability to connect via Ethernet to downstream, serially connected devices.
10. Designed accordingly to eco-design complying with ISO 14062, especially MCCB materials shall be halogen free type; designed for easy disassembly and recycling at end of life, and comply with environmental directives ROHS and WEEE.

11. The meter shall provide 4 digital inputs configurable for input metering with on-board pulse weight calculation and conversion to standard units for external water, air, gas, electrical or steam (WAGES) meters.

2.04 NAMEPLATES

A. Nameplates shall be provided in accordance with Section 26 05 00.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Operation and maintenance items as specified in Section 01 78 23.
   2. Manufacturer's product data with features and dimensions of devices.
   3. Burden, accuracy class, and ratio data for instrument transformers.

PART 3 EXECUTION

3.01 INSTALLATION

A. Accessories and devices shall be installed per the electrical distribution equipment manufacturer's instructions.

B. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer’s representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.

END OF SECTION

SECTION 26 09 16

ELECTRICAL CONTROLS AND RELAYS

PART 1 GENERAL

1.01 DESCRIPTION

A. The vendor, manufacturer, and custom control panels shall provide enclosures, selector switches, pushbuttons, indicators, terminal strips, surge devices, nameplates, testing procedures, wiring method, wiring color coding, wire labeling, separation between power, controls, and instruments, hardwired logic relays or PLC logic products as specified herein and in Section 40 67 00.

B. This section specifies electrical control and monitoring devices:
   1. Pushbuttons
   2. Selector Switches
   3. Indicating Lights
   4. Control Station Enclosures
   5. Horns
   6. Beacons
   7. Thermostats
   8. Elapsed Time indicators

C. This section specifies Control Relays:
   1. Load-Switching
   2. Logic Level Switching
   3. Timers
   4. Time Switch
   5. Alternators

D. This section specifies power devices:
   1. Overcurrent Protection:
      a. Circuit breakers
      b. Power Fuses
      c. Control Fuses
   2. Current transformers and transducers

E. This section specifies terminal strips, blocks, and devices.

F. This section specifies specialty contactors:
   1. Intrusion Switches
   2. Override Key Switches

G. Request clarification where conflicts occur with this section and other sections in Divisions 23, 26, 40, 43, and 46.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids.

C. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

D. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA ICS-1	General Standards For Industrial Controls and Systems
NEMA ICS-2	Industrial Control Devices, Controllers, and Assemblies

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00 and Section 40 67 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
    a. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
    b. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
    c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Arrangement drawings of the panel enclosure indicating the front door and panel equipment arrangement and dimensions, and enclosure type.

3. Nameplate legend with engraving and sizes.
4. Internal layout drawings showing all components.
5. List of materials and components with the layout drawings.
6. Elementary / schematic diagrams.
7. Internal wiring connection diagrams.
8. External wiring interconnection diagrams including interlocks.
9. Power and control single line diagrams, where motor controllers are included.
10. Manufacturer's catalog data for all material provided under this section shall be assembled in a folder with each page clearly marked with the item model number and reference number to the specification.
11. Operation and maintenance data as specified in Section 01 78 23 including approved submittal manufacturer's catalog data, as-built drawings, and instructions for all configurable or programmable components.

PART 2 PRODUCTS

2.01 CONTROL DEVICES

A. Pushbuttons:
   1. Pushbuttons shall be flush head, heavy-duty, with NEMA rating to match enclosure type. Operators shall be green for start function, red for stop functions, and black for all other functions. The escutcheon legend shall be as specified on the drawings.
      a. UL Listed.
      b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
      c. 30.5mm mounting hole.
      d. Temperature operating range -10 degree C. to +55 degree C.
      e. Momentary contact type.
      f. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
      g. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.
   2. Manufacturer: Allen-Bradley 800T/800H series or equal.

B. Selector Switches:
   1. Selector switches shall be heavy-duty with NEMA rating to match enclosure type. Selector switches shall have maintained position contacts. Switches shall be provided with contact blocks and number of positions as required performing the specified or indicated operations.
   2. The escutcheon legend shall be as specified on the drawings. Provide:
      a. UL Listed.
      b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
      c. 30.5mm mounting hole.

d. Temperature operating range -10 degree C. to +55 degree C.
e. Standard knob operator (not lever type nor wing lever type).
f. Number of positions and contact configuration as shown on Drawings.
g. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
h. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.

3. Manufacturer: Allen-Bradley 800T/800H series or equal.

C. Indicating Lights:
1. Red, amber, green, and blue indicating lights shall be heavy-duty full voltage 120Vac or 24Vdc push-to-test LED type with NEMA rating to match enclosure type for installation in a 30.5mm hole. Furnish with 28 chip high visibility LED. The escutcheon and lens color shall be as shown on Drawings or scheduled.
2. White indicating lights shall be as above, incandescent type lamp.
3. Manufacturer:
a. Allen-Bradley 800H-QRTH10 series or equal for 120Vac applications with colors other than white.
b. Allen-Bradley 800HQRTH24 series or equal for 24Vdc applications with colors other than white.
c. Allen-Bradley 800H-QRT10 series or equal for 120Vac applications with white.
d. Allen-Bradley 800H-QRT24 series or equal for 24Vdc applications with white.
4. Indicating Light Lens Color:

Lens Color	Typical Function	Example
Green	Danger, running, open	Equipment operating, motor running, valve open, power voltage applied, cycle in automatic
Amber	Fault condition, attention	Equipment failure, status abnormal
Red	Off, closed, ready	End of cycle; unit or head returned; motors stopped; motion stopped; contactors open, valve closed
White or Clear	Normal condition	Normal pressure of air, water, lubrication, control power on, status okay
Blue	Advisory	Control mode not in automatic

D. Control Station Enclosures:
1. Enclosures locations and ratings:
a. Indoors – conditioned space: NEMA 12.
b. Outdoors, process and Corrosive areas: NEMA 4X
c. NEC 500 Hazardous Areas: NEMA-7.

E. Horns:
1. The horn shall be a surface mount 120-volt AC enclosed buzzer and shall be Federal Signal Model 350WB (NEMA 4X); Model 31X (NEMA 7) or equal.

2. Each horn located standalone shall include a 6 x 10 inch Red with white letter lamacoid nameplate with the specific warning such as the following:
    a. DANGER GAS.
    b. VENTILATION SYSTEM FAILURE.
    c. As needed for each application.

F. Beacons:
1. The alarm beacon shall be a 75-watt sealed-beam lamp with motor driven rotating reflector; Beacon shall be for 120-volt AC service and shall be Federal Signal Model 191XL or equal.
2. Each beacon located standalone shall include a 6 x 10 inch Red with white letter lamacoid nameplate with the specific warning such as the following:
    a. DANGER GAS.
    b. VENTILATION SYSTEM FAILURE.
    c. As needed for each application.

G. Thermostats:
1. Thermostats shall be line voltage type with motor current rated contact and 70-degree to 140-degree Fahrenheit setpoint range.
    a. Manufacturer: Honeywell T631A-1022 or equal.

H. Elapsed Time Indicators:
1. Elapsed time indicators shall be panel mounted, non-resettable, 5.5-digit, hour indicator, rated 120Vac, 60-Hertz.
    a. Manufacturer: Trumeter 722-series or equal.

2.02 CONTROL RELAYS

A. Load-Switching Control Relays:
1. Control relays used for switching loads such as solenoids, actuators, contactors, motor starter coils, remote interlocking, etc. shall be heavy-duty machine tool type.
2. Contacts shall be 4-pole and be field interchangeable to either normally-open or normally- closed. Relay shall be capable of accepting a 4-pole adder.
3. AC relays shall have NEMA A600 contact ratings and electrical clearances for 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances for 250 volts.
4. Manufacturer:
    a. Allen Bradley Bulletin-700.
    b. Square D Class 8501.
    c. or equal.

B. Logic Level Switching Control Relays:
1. Control relays for signal circuits shall have a minimum of three SPDT, gold-flashed, fine silver contacts rated 10-ampere resistive at 120V AC or 28Vdc.
2. Control relays shall be plug-in type with heavy-duty, barrier-protected screw terminal sockets and clear polycarbonate dust cover with clip fastener.

3. AC models shall have neon lamp indicator wired in parallel with coil. DC models shall have LED lamp indicator wired in parallel with coil.
4. Manufacturer: Potter Brumfield series KUP; IDEC Series RH; or equal.

C. Timers:
1. Multi-function, micro-controller based, socket mounted timing relay.
2. Single functions:
   a. Delay on Make.
   b. Delay on Break.
   c. Recycle (on time first, equal recycle delays).
   d. Single shot.
   e. Interval.
   f. Trailing edge single shot.
   g. Inverted single shot.
   h. Inverted delay on break.
   i. Accumulative delay on make.
   j. Re-triggerable single shot.
3. Dual functions:
   a. Delay on make/delay on break.
   b. Delay on make/recycle (on time first, equal recycle delays.)
   c. Delay on make/interval.
   d. Delay on make/single shot.
   e. Interval/recycle (on time first, equal recycle delays).
   f. Delay on break/recycle (on time first, equal recycle delays).
   g. Single shot/recycle (on time first, equal recycle delays).
   h. Recycle – both times adjustable (on time first).
   i. Recycle – both times adjustable (off time first).
   j. Interval/delay on make.
   k. Accumulative delay on make/interval.
4. Time delay range, switch selectable:
   a. Single function 0.1 second to 1,705 hours in 8 ranges.
   b. Dual function 0.1 second to 3,100 minutes in 8 ranges.
   c. Setting accuracy +/- 1 percent or 50 milliseconds, whichever is greater.
   d. Repeat accuracy +/- 0.1 percent or 16 milliseconds, whichever is greater.
5. Output:
   a. Two Form-C electromechanical isolated contacts rated 10-amperes resistive at 240Vac.
   b. Rated 1/3-horsepower at 120 or 240Vac.
   c. Double-pole double-throw: DPDT.
   d. Mechanical life: 10,000,000 operations.
6. Electrical life: 1,000,000 operations at full load.
   a. Mounting: Magnal Plug 11-pin socket.

7. Environment: -20 to +65 degree C.
8. Manufacturer:
    a. ABB / SSAC's multifunction type TRDU time delay relay with dip-switch function setting with 12Vdc, 24Vac, 120Vac, 240Vac inputs as required or indicated or equal.

D. Time Switch:
1. Provide an electronic time switch with full-year control in a NEMA 1 enclosure. The switch shall incorporate a non-volatile memory that maintains programmed switching times for the life of the time switch and provide a factory installed field replaceable lithium or alkaline battery for time keeping and calendar information for a minimum of 8 years. Furnish with one single-pole, double-throw output switch rated 20-ampere at 240Vac. Furnish with manual override control.
2. Manufacturer:
    a. Intermatic Model ET2815CP.
    b. or equal.

E. Alternating Relay:
1. Alternate assignment between "Duty" and "Stand-by" at the end of each run cycle.
2. Double-pole, double-throw output relay rated for 7-amps inductive at 120-volts AC. Isolation not less than 1,500-volt RMS input to output. Life of 1,000,000 operations at full electrical load.
3. Switch to select alteration or continuous operation of either load.
4. Mount in Magnal 11-pin socket.
5. Operating temperature range of -20 to +60-degree C.
6. Manufacturer:
    a. ABB-SSAC type ARP series.
    b. or Engineer accepted substitute.

2.03 POWER DEVICES OVERCURRENT PROTECTION

A. Overcurrent Protection:
1. CIRCUIT BREAKERS: Circuit breakers shall be thermal magnetic, molded case type with the ampere rating as specified. Unless otherwise specified or indicated, circuit breaker interrupting rating shall be 18,000 amperes symmetrical.
2. POWER FUSES: Provide Class R fuses and fuse holders where required for proper protection of equipment. Fuse clips shall be Class R rejection type and sized for UL Class R, one-time, time-delay fuses. Fuse assembly shall have a minimum short circuit capacity of 100,000 amps symmetrical. Provide fuses as shown and one set of spare fuses with each switch.
3. CONTROL FUSES: Fuses for 120 Vac circuits shall have a minimum of 12,000-amperes interrupting capacity and blown fuse indicators. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments. Fuse holders shall be tip-out or draw-out type.

B. Current Transformers And Transducers:
   1. Provide monitoring current transformers with 600Vac insulation and primary ampere rating as indicated with 5-ampere output.
   2. Provide AC current transducer for any one of the phase conductors of the power circuit to be installed through onboard toroid. Provide a loop-powered transducer with input rated from 0 to 50 ampere with 4-20madc analog output scaled for the primary current of the current transformer. Provide zero and span adjustments.
   3. Provide a DIN rail or back plate mounted AC current transducer that is a loop-powered transducer with input rated from 0 to 5-ampere and with 4-20madc analog output scaled for the primary current of the current transformer.
   4. Manufacturer:
      a. ABB AC current transducer DCSA Series Loop Powered and mounting accessories, or equal.
      b. ABB AC current transducer TCSA Series Loop Powered and mounting accessories, or equal.

2.04 TERMINAL STRIPS, BLOCKS, AND DEVICES

A. Power Wiring: Provide back plate mounted terminal strips rated at 600 Vac.

B. Control Wiring: Provide a DIN rail with spring powered contact rated at 300 Vac 24 ampere with pluggable terminals.

C. Terminal identification standard to the product provided.

D. Manufacturer:
   1. Standard: Allen Bradley or equal.
   2. Standard: DIN rail: Phoenix Contact or Weidmuller Z-Series.

2.05 SPECIALTY CONTACTORS

A. Intrusion Device:
   1. The intrusion switch shall be wide-gap industrial grade magnetic door switch with maximum gap 2.5 inches between the sensing elements. The magnet element shall be mounted on the moving part of the door. The sensor switch shall close when the door is closed. The sensor switch shall open when the door is opened. Provide with appropriate mounting bracket for the entrance doors.
   2. Manufacturer:
      a. George Risk Industries Series 4400.
      b. or equal.

B. Override Key Switch:
   1. The override key switches shall be access control type with mortise cylinder and 24 Vdc single pole double threw (SPDT) maintained contacts.

C. Manufacturer:
   1. Schlage 650 Series Keyswitches.
   2. or equal.

2.06 NAMEPLATES

A. Nameplates for all control stations, relays, timers, and motor contactors shall be provided in accordance with the requirements of Section 26 05 00-2.04.

PART 3 EXECUTION

3.01 INSTALLATION

A. Control stations shall be mounted 48 inches above the floor, ground, or slab to center of device.

B. Devices shall be tested in accordance with Section 26 05 00 and Section 26 08 00.

END OF SECTION

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SECTION 26 21 16

LOW-VOLTAGE UNDERGROUND ELECTRICAL SERVICE ENTRANCE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies outdoor rated, 480Vac, four-wire, Service Entrance Section (SES) with Rocky Mountain Power power utility metering equipment and main disconnecting means as shown on the drawings.

B. The SES shall consist of the following:
   1. Enclosure Section-1:
      a. Power utility metering compartment that meets the EUSERC standards in an outdoor NEMA-3R, non-walk-in enclosure.
   2. Enclosure Section-2:
      a. Includes the fixed insulated-case power circuit breaker with solid state trip "Main" circuit breaker
      b. Ground fault interrupting system initially set to the maximum setting
      c. Transient voltage surge suppresser (TVSS)

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/IEEE	Definitions and Requirements for 600 Volt Air Switches, Insulators, and Bus Supports
ANSI C37.46	Specifications for Power Fuses and Fused Disconnecting
ANSI C37.47	Specifications for Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses
NEMA PB 2	Deadfront Distribution Switchboards

Reference	Title
UL 489	Underwriters Laboratory – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 891	Underwriters Laboratory - Deadfront Switchboards
UL 943	Underwriters Laboratory – Ground-Fault Circuit-Interrupters
UL 977	Underwriters Laboratory – Fused Power-Circuit Devices
UL 1066	Underwriters Laboratory – Low Voltage AC and DC Breakers used in Enclosures

B. Factory Tests:
   1. Switchboards shall be tested for operation at the specified voltage and current ratings after assembly. The main circuits shall be given a dielectric test of 2200 volts for 1 minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for 1 minute between live parts and ground.
   2. Instrument transformers shall have ratio and phase angle tests made in conformance with ANSI C57.13.

1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01 33 00.
   1. Electrical single line, schematic diagrams, and conductor connection diagram.
   2. Layout drawings indicating arrangement, dimensions, cable entries, and weights.
   3. Manufacturer's product and catalog data indicating equipment specifications and features including interrupting, withstand, and continuous current ratings of all relevant equipment and components. Catalog data shall be edited or “arrowhead” to indicate only the models and options to be provided as part of this specification.
   4. Manufacturer’s procedure for ground-fault performance test.

B. The SES submittal information shall also be submitted to Power Utility Metering Department for their approval.

C. After Power Utility approval, submit one approved copy with Utility comments to the Engineer.

1.04 PROJECT / SITE CONDITIONS

A. The equipment shall be designed and manufactured to meet the specified requirements of Sections 01 11 80 and 01 73 24 for environmental and seismic conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
   1. Eaton Cutler-Hammer
   2. General Electric Co.
   3. ABB
   4. Siemens
   5. or equal

2.02 SERVICE ENTRANCE SECTION

A. General:
   1. Coordinate with Power Utility for the correct meter socket, test devices, potential transformers, current transformers, and other items installed in the metering section. Refer to Power Utility Electric Service Requirements, latest edition.
   2. Equipment and materials shall be new and free from defects.
   3. Continuous Current Ratings: As shownat 600Vac.

B. Power Disconnect – Fused Switch Device Type:
   1. The high-pressure contact-switch shall provide a stored energy operating mechanism, Class-L fuse coordination for 200,000-ampere root mean squared (rms) interruption and isolation, and self-powered ground-fault protection with time and current field adjustments.

C. The following components shall be provided:
   1. Emergency switch-open button that triggers the stored energy operating mechanism with positive "On-Off" indication and with an entrance door - power disconnect switch safety interlock.
   2. Blown Fuse-Protection: Provide single-phase protection when only one fuse is blown.
   3. Test Buttons:
      a. No-trip Ground Fault Test Button: Permits ground fault test without tripping the SES switch.
      b. Test Button: Simulates ground-fault occurrence and trips the SES switch.
      c. Provide an external 120Vac control power source for test function.

D. Power Disconnect - Circuit Breaker Type:
   1. The circuit breaker with adjustable solid-state trip with sizes as indicated. The circuit breaker settings shall be confirmed with a protective device coordination study provided by others.
      a. General:
         1) Circuit breakers shall be stored energy type mechanism to provide quick-make, quick-break, trip-free operation:
            a) Insulated case UL listed 100 percent continuous current capacity.
            b) Ground fault protection shall be provided as specified or indicated.
      b. Circuit breakers shall provide manual switching operation by means of a low-torque handle or pushbutton on the front of the unit. Automatic operation during overload and short circuit conditions shall be provided by solid state or thermal magnetic tripping devices located in the circuit breaker frame as specified on the drawings.
      c. Circuit breakers shall be front accessible, stationary, individually mounted, and shall have short circuit capabilities equal to or greater than the system in which they are installed. Unless otherwise noted, circuit breakers shall have a minimum interrupting current of [65,000] amperes symmetrical RMS at 480 Vac.
      d. Static Tripping Devices:
         1) Solid state static tripping devices shall consist of current sensors, logic assembly, magnetic latch release, and required interconnecting wiring. Tripping devices shall be automatic and self-contained within the breaker frame and shall not require any external relaying or power supplies.
      e. Tripping functions shall be field adjustable and contain the following tripping characteristics:
         1) Overload tripping:
            a) Adjustable ampere setting
            b) Adjustable long-time delay
         2) Short circuit tripping:
            a) Adjustable short-time pickup
            b) Adjustable short-time delay
            c) Adjustable instantaneous pickup
         3) Ground fault tripping:
            a) Adjustable ground fault pickup
            b) Adjustable ground fault delay
   2. Power Bus:
      a. The bus shall be insulated tin-plated copper bus bar. Unless otherwise specified, buses shall be braced to withstand short circuit stresses up to 65,000 RMS amperes.
   3. Enclosure:
      a. The enclosure shall be designed for outdoor installation. Each of the enclosure sections shall have a full-length flanged front door.
      b. The structure supporting current carrying parts shall be flame retardant non-tracking glass polyester or porcelain.

4. Safety Interlocking:
    a. The inner door shall be hinged and interlocked with the main circuit breaker or fused switch so that the power disconnecting device opens before internal access is possible and the door must be closed before the power disconnecting device may be closed.
5. Lightning Arrestor and Surge Capacitor:
    a. Provide a lightning arrestor and surge capacitor for 480Vac service entrance sections cabinets:
        1) Silicon Oxide Varistor (SOV)
        2) Energy Rating: 3000 joules per pole.
        3) Time Rating: 5 nanoseconds.
        4) Resistors: Prohibited.
        5) Manufacture and Models:
            a) Delta LA-603 for 3-phase, 3-wire or equal.
            b) Delta LA-603 for 3-phase, 4-wire or equal.
            c) Delta CA-603 for 3-phase, 3 or 4-wire rated at 650 Vac, or equal.
6. TVSS Surge Device:
    a. Refer to Section 26 43 13 for additional TVSS requirements. Provide a transient voltage surge suppressor (TVSS) rated at:
        1) 480Y/277 Vac
        2) 150,000 ampere per phase with 5-nanosecond response time
        3) Five-year manufacturer warrantee with UL Label.
        4) Features:
            a) Fault monitoring.
            b) Trouble monitoring.
            c) Strike counter.
        5) Manufacturer: ABB, Eaton/Cutler Hammer, GE, Square D, Transtector-Facility Protector, or equal product.
7. Grounding:
    a. A common ground bus shall extend the entire length of the assembly with ground lugs furnished at each end where multiple enclosures are attached together. A ground lug, sized for a 4/0 bare copper ground wire, shall be bolted to the interior of the enclosure.
8. Neutral:
    a. A neutral bus shall extend the entire length of the assembly with lugs furnished at each end where multiple cabinet enclosures are attached together.
9. Finish:
    a. The finish shall comply with in accordance with Section 26 05 00.
10. Nameplates:
    a. In addition to the manufacturer's identification, an external nameplate shall be provided with equipment number and name as shown.

b. Each section compartment shall be provided with nameplates indicating utility meter, main breaker circuit name with equipment number and description of load, pull sections, TVSS, and any additional designations describing the compartment function or usage.

c. Provide nameplates per Section 26 05 00. Provide nameplates for power sources indicating the power loads and nameplates for power loads that indicate the power sources, in accordance with these specifications and the NEC.

11. Wiring:

a. Internal switchboard wiring shall consist of single conductor SIS 90 degree C copper wire and UL listed for panel wiring. The wire shall be sized to suit load requirements. Minimum size shall be No. 14 AWG.

2.03 ARC FLASH MITIGATION METHODS

A. The following mitigation method requirements shall apply to all power distribution and utilization equipment supplied for any products supplied on the project and applies to all equipment divisions in the Contract Documents. Refer to the NFPA-70 (NEC), and NFPA-70E (NESC) for equipment labeling requirements.

B. Equipment Labels:

1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.

C. Power and Control Equipment Separation:

1. Provide separation between power equipment within an enclosure, cabinet, or panel by the uses of barriers, separate access doors, or by other means.
2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.

D. Automatic Shutters:

1. Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.

2.04 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:

1. Applicable operation and maintenance information shall be provided in the product submittal, including:
   a. As-built drawings.
   b. Final, complete, reviewed submittal information.
   c. Manufacturer's Circuit Breaker instructions.
   d. Manufacturer's TVSS instructions.
2. Results of factory tests conducted in accordance with paragraph 1.02 Factory Tests.
3. Results of field tests conducted in accordance with paragraph 3.04.
4. Ground-fault protection performance test.

PART 3 EXECUTION

3.01 INSTALLATION AND INSPECTION

A. Coordinate the SES conduit installation with the power utility and request their inspection of the work prior to covering up the work.

3.02 PROTECTIVE DEVICE SETTING COORDINATION

A. Refer to Section 26 05 74 for Short Circuit and Protective Device Coordination Studies and Section 26 08 00 for device setting implementation requirements and Arc Flash labeling requirements.

3.03 PROTECTIVE DEVICE SETTINGS

A. The power utility metering instrument transformer ratios shall be confirmed with the power utility metering department.

B. The protective devices shown on the drawings are preliminary and are subject to confirmation with the coordination study in Section 26 05 74.

C. The ground fault protective device and the fuses or tripping devices shall be adjusted to the settings specified in the protective device coordination study in Section 26 05 74 prior to energizing the SES.

3.04 FIELD TESTING

A. The SES equipment shall be tested in accordance with Section 26 08 00. Verify the ground fault setting and trip functions. Perform ground-fault protection performance test per Manufacturer instructions. Provide written successful test results.

END OF SECTION

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SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies dry-type transformers with primary winding rated 600 volts and less used for power distribution, lighting and control purposes as specified or shown.

B. This section specifies mini-power centers that include the primary transformer protection, transformer, secondary protection and a circuit breaker panel in one package.

C. This section specifies K-Rated transformer with electro-magnetic shielding.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers
ANSI/UL 506	Specialty Transformers
DOE	10 CFR Part 431 Efficiency Standards
NEMA ST20	Dry-Type Transformers for General Application

1.03 RATINGS AND STANDARDS

A. Transformers rated:
   1. 10 kVA and smaller shall be single phase or as indicated.
   2. 15 kVA and greater shall be 3 phase or as indicated.
   3. Voltage, frequency, number of phases and kVA as indicated.
   4. Conform to ANSI/IEEE C57.12.01, DOE 10 CFR Part 431 Efficiency Standards, NEMA ST20, and ANSI/ UL 506.

1.04 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's data.
   2. Dimension and rating data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
   1. ABB
   2. Eaton Cutler-Hammer
   3. Siemens
   4. Square D
   5. or equal.

Ambient Temperature	+ Winding Temperature Rise	+ Hot Spot	= Temperature Class
40-d C	80-d C	30-d C	150-d C
40-d C	115-d C	30-d C	185-d C
40-d C	150-d C	30-d C	220-d C

2.02 INSULATION

A. Transformers temperature rise based on 40-degree C ambient temperature:
   1. 15 kVA and above: Not exceed [80] [115] [150] degree C temperature rise.
   2. below 15 kVA: Not exceed [80] [115] degree C temperature rise.

2.03 COILS

A. Transformer coils:
   1. Copper
   2. 15 kVA and above:
      a. Impregnated with varnish.
   3. 10 kVA and below:
      a. Encapsulated.

2.04 WINDING CONFIGURATION

A. Transformers shall have electrically isolated primary and secondary windings. Primary and secondary winding configurations shall be as specified or shown. Provisions shall be made to permit separate grounding of the neutral conductor and the enclosure. Single-phase transformers shall be the four winding type.

2.05 TRANSFORMER TAPS

A. Transformers 15 kVA and above shall be provided with two 2-1/2 percent full capacity taps above normal voltage and four 2-1/2 percent full capacity taps below rated voltage on the primary winding.

2.06 TERMINAL COMPARTMENTS

A. Terminal compartments shall be sized to permit termination of cables specified. Terminal connections shall be made in the bottom third of the enclosure. The terminals shall be copper and sized for the cable specified.

2.07 ENCLOSURES

A. Transformers enclosures:
   1. 15 kVA and smaller:
      a. Weatherproof, nonventilated enclosures.
   2. Indoor over 15 kVA:
      a. Dripproof, ventilated enclosures.
   3. Outdoor:
      a. Weatherproof enclosures.

2.08 MOUNTING

A. Transformers 25 kVA and below shall be suitable for wall mounting and include mounting brackets and hardware. Transformers over 25 kVA shall be floor mounting type.

B. See specification 01 73 24 for seismic requirements.

2.09 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of Section 26 05 00-2.04.

2.10 SOUND LEVELS

The sound levels shall not exceed the following values:

kVA	dB
0 - 9	40
10 - 50	45
51 - 150	50
151 - 300	55
301 – 500	60
501 – 700	62
701 - 1000	64

2.11 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's verification that the unit has been built and tested in accordance with the specified ANSI standards.
   2. Manufacturer's verification of the sound levels, if different from the specified NEMA ST20 standards.
   3. Applicable operation and maintenance information as specified in Section 01 78 23.
   4. Manufacturer's product literature.

PART 3 EXECUTION

3.01 GENERAL

A. Bond transformer enclosures and neutrals together and connect to the ground grid.

3.02 INSTALLATION

A. Install transformers on walls or floors at locations shown on the Drawings. Install floor mounted transformers on raised concrete bases. Provide sufficient access and working space for ready and safe operation and maintenance.

B. Mount transformers so that vibrations are not transmitted to the structural parts of the building or to other equipment. Make connections to transformers with flexible conduit.

C. Adjust tap settings to provide proper voltage at panelboards.

D. Ground transformer in conformance with the National Electrical Code.

3.03 TESTING

A. Transformers shall be tested in accordance with Section 26 08 00.

END OF SECTION

SECTION 26 23 00

LOW-VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies switchgear rated 600 volts, 3 phase, 60 Hertz for power distribution with drawout circuit breakers and associated electrical metering. Switchgear features include:
   1. Automatic Transfer Controller (ATC) PLC
   2. Uninterruptible Power Supply
   3. Power Monitors

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Structural Design and Anchorage Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 26 05 00 Common Work Results for Electrical
   3. Section 26 05 74 Arc Flash Analysis Shot Circuit Study
   4. Section 26 08 00 Commissioning of Electrical Systems
   5. Section 26 43 13 Surge Protective Devices for Low-Voltage Electrical Power Circuits

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/IEEE C37.13	Low Voltage AC Power Circuit Breakers Used in Enclosures
ANSI/IEEE C37.16	Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI/IEEE C37.17	Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers

Reference	Title
ANSI C37.20	Switchgear Assemblies Including Metal Enclosed Bus
ANSI/IEEE C37.20.1	IEEE standard for Metal-Enclosed Low-Voltage-Power Circuit Breaker Switchgear
ANSI/IEEE C37.20.7	Guide for Testing Metal-Enclosed Switchgear Rated Up to 38kV for Internal Arcing Faults
ANSI C37.50	Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures
ANSI/IEEE C37.51	Switchgear - Metal-Enclosed Low-Voltage AC Power- Circuit-Breaker Switchgear Assemblies - Conformance Test Procedures
ANSI/IEEE C57.13	Requirements for Instrument Transformers
ANSI/IEEE C62.41	Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
ANSI/IEEE C62.45	Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
CSA 22.2 No 31-10	Switchgear Assemblies
IBC	International Building Code
NEMA SG-3	Low Voltage Power Circuit Breakers
NEMA SG-5	Power Switchgear Assemblies
UL 1066	UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers
UL 1449	Transient Voltage Surge Suppressors
UL 1558	UL Standard for Safety for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.04 CODES AND STANDARDS

A. Work shall conform to or exceed the applicable requirements of the National Electric Code (NEC); provided, that where a local code or ordinance is in conflict with the NEC, the provisions of said local code or ordinance shall take precedence.

B. LV Switchgear shall be Underwriters Laboratory listed to UL 1558.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meetings:
   1. Conduct (1) one 2-hour workshop with the Owner and Engineer, answer questions, solicit feedback,and present the following:
      a. Draft HMI Screen Graphics.
      b. Draft Automatic-Transfer-Controller (ATC) Sequence of Operation.
      c. Draft Hard-wire interlock construction.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, and those listed below with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. A copy of the drawings (one line diagrams, wiring diagrams, and network diagrams) with a check mark to indicate compliance with the drawing a whole. If deviations from the drawing are indicated, and therefore requested by the Contractor, each deviation shall be circled and denoted by a number, referenced to a detailed written explanation of the reasons for requesting the deviation.
5. Catalog cuts of equipment, devices, and materials in Part 2 Products.
    a. Manufacturer's data indicating momentary, interrupting, and continuous current ratings of all relevant equipment, components, and devices.
    b. Manufacturer's catalog data indicating materials and features of construction and information on control features and components.
    c. Protective device data: Characteristic curves and instructions for coordination and settings of protective relays.
6. Outline and Arrangement Drawings completely dimensioned, shall show:
    a. Plan view, front view, other elevation views, if pertinent
    b. Equipment arrangement
    c. Required clearances for opening doors and for removing breakers
    d. Location and size of all conduit entrance provisions for user's power and control connections
    e. Bus configuration and dimensions
    f. User's interface wiring terminal blocks locations and details
    g. Grounding connections
    h. Weight of equipment by vertical section of switchgear
    i. Location, size, and loads on hold-down bolts, details of embedded channels and detail seismic bracing and anchoring
7. Seismic design drawings, calculations, and data as specified in Section 01 73 24.
8. Diagrams:
    a. Single-line Diagrams with ANSI device function numbers used throughout shall show:
        1) Circuit breakers
        2) Instrument transformers
        3) Relays
        4) Meters
        5) Switches, test switches, and shorting type terminal blocks

b. Elementary Diagrams
    1) An elementary diagram shall be furnished for the electrically operated breaker control scheme.
    2) The elementary diagram shall show all related control devices and device contacts, each of which shall be labeled with its proper ANSI device function number.
    3) Three-line diagrams of potential and current secondary circuits showing device terminal numbers and internal diagrams.
    4) All diagrams shall be computer generated.
c. Detailed Connection (Wiring) Diagram shall show:
    1) Approximate physical location of all items in the section.
    2) All wiring in the section.
    3) All interconnecting wiring between the sections.
    4) Identification of all terminals, terminal blocks, and wires.
    5) Spare auxiliary contacts and relay contacts wired to terminal blocks for future use.
d. Schematic diagrams of control and alarm circuits. Schematics shall be computer generated. Schematic diagrams shall show part numbers for all devices.
e. Network drawings.

9. A complete bill of material separated into each subassembly and showing manufacturer's part number, quantity and description of each part. If another manufacturer makes the part, the description shall indicate the other manufacturer and their part number.
10. ATC Functionality:
    a. A complete description of system operating sequences.
    b. Written overview of the switchgear PLC control logic explaining the sub-routine program including control, monitoring, alarming and interlock functions.
    c. Annotated PLC application program logic code, with a written control description that describes the application program code in non-technical terms using clear sentence structure that includes sequence of events, interlocks, and action on fault conditions. Hard copy and electronic copy shall be provided in native program and PDF.
11. SCADA:
    a. Switchgear configuration parameters available to be read/written by the Owner's SCADA system, with register address, bit assignment, and setting value (range of value). Vendor shall indicate which, if any, parameters the switchgear requires from the Owner's SCADA for automated operation of the switchgear.
    b. Interconnection Diagrams for SCADA interface shall show:
        1) All wiring from the breaker controls to terminal strips located within an accessible section of the Switchgear section for monitoring of:
            a) Breaker 86 Tripped Status to SCADA (From Protective Relays)
            b) Breaker Closed Status to SCADA
            c) Utility Status (Bus A) to SCADA
            d) Utility Status (Bus B) to SCADA
            e) Breaker Racked In/Out Status to SCADA

12. Full color operator interface terminal (OIT) submittal shall be provided including the following:
    a. OIT application program graphics/code which achieves the functions specified. Hard copy and electronic copy shall be provided in native program and PDF.
    b. Updated control description detailing the PLC control program as it relates to the OIT graphics in terms of operator control set points, status, and indications.
13. Test Plans:
    a. Factory Test Plan
    b. Field Test Plan
14. All diagrams, schematics, interconnections, layouts and details submitted shall be on 11-inch by 17-inch reproducible bond, as well as in Autodesk MEP 2012 and pdf file formats with details clearly legible. Supplier shall submit both bond and drawing data files.

B. Informational Submittals:
    1. Procedures: Section 01 33 00.
    2. Arrangement and layout drawings of the switchgear enclosures depicting equipment and bus arrangement and dimensions including areas of permissible cable entries. A list of material and components shall accompany the layout drawings.
    3. Catalog data and instruction manuals on all electrical devices and components mounted on or within the switchgear.
    4. Results of factory tests as specified in this Section and Section 26 08 00.
    5. Supplier's certification and calculations that the equipment meets the seismic requirements of Section 26 05 00 and Section 01 73 24.
    6. Loading and unloading procedures.
    7. Installation instructions covering all the equipment furnished including all circuit breakers, protective relays, metering, etc.
    8. Warranty information.

C. Closeout Submittals:
    1. Procedures: Section 01 78 23.
    2. Results of field tests and field breaker setting tests as specified in this Section and Section 26 08 00.
    3. Operations and Maintenance Manuals (including Warranty) in accordance with Section 01 78 23.
    4. Information verifying that the current and potential transformers configuration is per the power monitor manufacturer’s requirements for the power monitors as specified within this Section.
    5. Information required to verify that the differential current transformers meet the performance requirements specified in this Section.
    6. Spare parts:
        a. Procedures: Section 01 33 00.
        b. Complete recommended spare parts list, including parts location diagrams or drawings.
        c. List of priced spare parts that Supplier recommends should be on hand during switchgear start-up and the first year's operation.

1.07 QUALITY ASSURANCE

A. Qualifications:
   1. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
   2. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
   3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
   4. Provide Seismic tested equipment as follows:
      a. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the latest International Building Code (IBC).
      b. The Project Structural Engineer will provide site specific ground motion criteria for use by the manufacturer to establish SDS values required.
      c. The IP rating of the equipment shall be 1.5
      d. The Structural Engineer for the Site will evaluate the SDS values published on the Manufacturer's or OSHPD website to ascertain that they are "equal to" or "greater than" those required for the Project Site.
      e. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
         1) The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
         2) The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
         3) The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

B. Factory Tests:
   1. Factory Testing shall be performed by the Supplier prior to delivery in order to verify the accuracy and performance of the systems as specified. Factory Testing need not be witnessed by the City Representative, unless a special Witness Testing paragraph is included in this Section. However, the Supplier shall certify and provide copies of the tests and guarantee the equipment's performance as specified in this Section. All certifications of Factory Testing shall be submitted and approved by the City Representative, prior to shipping equipment.

2. Factory Testing shall include at the minimum all standard tests recommended by the Supplier and the following:
    a. Operation at the specified voltage and current ratings. The main circuits shall be given a dielectric test of 2200 Volts for 1 minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 Volts for 1 minute between live parts and ground.
    b. Instrument transformers shall have ratio and phase angle tests made in conformance with ANSI C57.13. Three copies of test results shall be submitted.
    c. Automatic Transfer Controller (ATC) and Human Machine Interface (HMI) functionality.

C. Contractor (Equipment Supplier, as applicable) shall provide a 2 year warranty.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01 66 00.

B. Loading and unloading per manufacturer's instructions.

1.09 WARRANTY

A. The manufacturer shall warrant that products supplied are free from defects in material or workmanship and shall repair or replace defective products for a period of 24 months provided that the manufacture performs functional testing, commissioning and first parameter adjusting of equipment. The warranty period shall begin after the Owner utilizes the equipment or partial/substantial completion has been attained - whichever comes first. The start of this period shall not exceed 18 months from equipment energization or shipment date of equipment. This warranty shall be in addition to any provided by the Contractor. The warranty shall exclude normal wear and tear under normal usage and any damage caused by abuse, modification, or improper maintenance by entities other than the manufacturer or its approved representative.

B. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
    1. Eaton
    2. ABB

3. Schneider Electric
4. or approved equal

2.02 EQUIPMENT

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Enclosure:
   1. Switchgear shall be factory assembled and metal enclosed. Each unit shall consist of a stationary structure assembly and one or more air circuit breaker units, disconnecting devices, and other specified equipment. Each unit shall be provided with a breaker hoist for removing the breaker for maintenance. The breaker hoist shall be mounted on the top of the structure.
   2. Main Breakers shall be installed in end of line up vertical sections. No other feeder breakers shall be installed within the main breaker vertical sections.

C. Stationary Structure:
   1. Stationary structure shall be a self-contained steel unit housing one or more individual breakers or instrument compartments and a rear compartment for buses and outgoing cable connections.
   2. Structure shall be provided with removable steel plates on the top and sides, and each breaker compartment shall be equipped with primary and secondary contacts, rails, and stationary levering mechanism.
   3. Structures shall be provided with horizontal and vertical barriers to separate different voltage classes, buses and cables:
      a. Separate different voltage classes.
      b. Separate bus compartments from cable compartments.
      c. Separate cable compartments between vertical sections.
   4. Structure shall be provided with a rear hinged cover for each cable compartment and a front hinged door for each breaker and metering compartment.
   5. Minimum depth: 72”
   6. Maximum depth: 84”

D. Finish:
   1. Electrical equipment shall be treated with zinc phosphate, bonderized or otherwise given a rust-preventive treatment. Equipment shall be primed, coated with enamel, and baked. Minimum dry film thickness shall be 3 mils.
   2. Color: Exterior color of electrical equipment shall be ANSI 49 or ANSI 61 light gray. Interior shall be painted white.

2.03 BUS BARS

A. General:
   1. Buses shall be tin-plated copper and shall be insulated where accessible to maintenance personnel.

B. Main Bus:
   1. Main horizontal bus shall extend through all sections of the switchgear with vertical connections to circuit breakers in each section.
   2. Main bus shall have a continuous rating at least equal to the main circuit breaker and shall be braced to withstand stresses resulting from the maximum short-circuit current available. Minimum bracing shall be 65,000 amperes symmetrical (SCCR).
   3. Buses shall be mounted on heavy-duty glass polyester supports, and main bus joints shall be tin-plated and bolted using a minimum of two bolts.
   4. Shipping splits and provisions for future bus extensions shall have silver-plated bolted connections.

C. Ground Bus:
   1. A ground bus having a momentary rating at least equal to the highest momentary rating of any circuit breaker in the assembly shall extend the length of the bottom of the switchgear. Each end of the ground bus shall be provided with clamp type terminals for No. 4/0 bare copper ground wire.

2.04 CIRCUIT BREAKERS

A. General:
   1. Breaker element shall consist of a three-pole electrically operated with solid state overcurrent trip device, arc quenchers, manual stored energy closing mechanism, mechanical pushbutton trip and position indicator.
   2. Breakers shall have a minimum interrupting current of 65,000 amperes symmetrical RMS at 480 Vac. Breaker element shall be suitable for mounting on the drawout mechanism in the circuit breaker compartment. Electrically operated circuit breakers shall be capable of operating on 80 to 120 Vac control power.
   3. Provide a breaker test circuit appliance and device.

B. Disconnecting Devices and Drawout Mechanism:
   1. Disconnecting devices shall be the self-aligning type with the disconnecting fingers mounted on the breaker. The drawout mechanism shall rigidly hold the circuit breaker in the fully connected, test, and fully disconnected positions. Interlocks shall be provided to prevent moving the circuit breaker from the fully connected, test, or fully disconnected positions unless the breaker is open. Interlocks shall also prevent closing the breaker between any of these positions.
   2. The drawout mechanism shall be designed so that the breaker can be racked to any position without opening the door. A hasp on the breaker escutcheon shall be provided that can receive three padlocks when the breaker is in the open position.

C. Auxiliary Switches:
   1. Breakers shall be equipped with four (4) normally open and four (4) normally closed auxiliary switches or eight (8) Form-C contacts rated 10 amperes, 120 volts, and wired to terminal blocks.

D. Solid State Tripping Devices:
   1. Solid state tripping devices shall consist of current sensors logic assembly, magnetic latch release, and required interconnecting wiring. Tripping devices shall be automatic and self-contained within the breaker frame, and shall not require any external relaying or power supplies.
   2. Tripping device shall be provided with manually resettable fault indicators. As a minimum, fault indicators shall provide indication of tripping caused by overload, short circuit or ground fault.
   3. Tripping functions shall be field adjustable and shall provide, as specified, the following tripping characteristics:
      a. Overload Tripping:
         1) Adjustable ampere setting
         2) Adjustable long-time delay
      b. Short Circuit Tripping:
         1) Adjustable short-time pick-up
         2) Adjustable short-time delay
         3) Adjustable instantaneous pick-up
      c. Ground Fault Tripping:
         1) Adjustable ground fault pick-up
         2) Adjustable ground fault delay
   4. The trip units shall utilize ARMS (Arcflash Reduction Maintenance System), Energy Reduction Maintenance Setting (ERMS) or equal. ARMS / ERMS shall be provided in a system that shall reduce the trip unit Instantaneous pickup value when activated. ARMS / ERMS device shall not compromise breaker phase protection even when enabled. Once ARMS /ERMS unit is disabled, the recalibration of trip unit phase protection shall not be required. Activation and deactivation of ARMS / ERMS setting shall be accomplished without opening the circuit breaker door and exposing operators to energized parts. ARMS / ERMS shall provide a clearing time of 0.04 seconds, adjustable with a minimum of five settings ranging from 2.5X to 10X of the sensor value.
      a. ARMS / ERMS shall be enabled via a switch on the trip unit. It shall also provide confirmation of protection via a Blue LED.
      b. ARMS / ERMS shall be provided with remote “enable/disable” control
      c. ARMS / ERMS shall be provided with a switchgear panel mounted enable padlockable selector switch and indication via Blue LED pilot light.

2.05 PANEL INSTRUMENT AND ACCESSORIES

A. Panel instrument and accessories shall be provided as the manufactures standard offerings for panel instrument and accessories that are rated for metering services and that include potential and current transformers with the standard associated protective and testing devices.

2.06 PROTECTIVE RELAYING

A. Protective relaying shall be as specified. The tripping devices and instrument transformer ratios specified are preliminary and are subject to confirmation with the protective devices coordination study in Section 26 05 74.

2.07 EQUIPMENT IDENTIFICATION

A. Nameplates:
   1. In addition to the manufacturer's identification, switchgear shall be provided with phenolic nameplates showing switchgear, main breaker, and feeder breaker designations as specified. Nameplates shall comply with Section 26 05 00.

B. Conductor Markers:
   1. Conductor markers shall comply with Section 26 05 00.

2.08 WIRING

A. Conductors:
   1. Internal switchgear wiring shall consist of single conductor SIS 90 degree C copper wire and UL listed for panel wiring. The wire shall be sized to suit load requirements with the minimum size of No. 14 AWG.

B. Terminal Blocks:
   1. Terminal blocks shall comply with Section 26 05 00.

C. Cable Connectors:
   1. Cable connectors for outgoing power cables shall be suitable for use with aluminum or copper conductors. They shall be UL listed as a compression connector and shall be sized for the specified conductor.
   2. Conical washers shall be used for each connection.

2.09 ARC FLASH MITIGATION METHODS

A. The following mitigation method requirements shall apply to all power distribution and utilization equipment supplied for any products supplied on the project and applies to all equipment divisions in the Contract Documents. Refer to the NFPA-70 (NEC), and NFPA-70E (NESC) for equipment labeling requirements.

B. Equipment Labels:
   1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture’s data or the equipment ratings.

C. Hinged Doors:
   1. Power distribution equipment shall have hinged rear doors where back access is shown.

D. Remote Racking Devices:
   1. Power distribution equipment shall have remote racking devices for Operators to insert or remove rack-mounted breakers, rack-mounted devices, or auxiliary equipment drawers into the associated equipment location.

E. Insulated Power Bus and Insulated Cable Boots:
   1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
   2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.

F. Power and Control Equipment Separation:
   1. Provide separation between power equipment within an enclosure, cabinet, or panel by the uses of barriers, separate access doors, or by other means.
   2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.

G. Automatic Shutters:
   1. Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.

2.10 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Arrangement and layout drawings of the switchgear enclosures depicting equipment and bus arrangement and dimensions including areas of permissible cable entries. A list of material and components shall accompany the layout drawings.
   2. Catalog data and instruction manuals on all electrical devices and components mounted on or within the switchgear.
   3. Results of factory tests and field breaker setting tests as specified in paragraphs 1.02 Factory Tests and 3.02.
   4. Operation and maintenance information as specified in Section 01 78 23.
   5. Manufacturer's product information.
   6. Manufacturer's certification and calculations that the equipment meets the seismic requirements of Section 01 73 24-1.03.

2.11 POWER QUALITY METERS

A. Provide power monitors for each bus.
   1. Capable of monitoring and recording the following information:
      a. Instantaneous values:
         1) Current: A, B, and C phase.
         2) Voltage: Phase-to-phase and phase-to-neutral.
         3) Watts, VARs, VA.
         4) Power factor (Apparent and Displacement)
         5) Frequency.

6) THD:
a) Voltage – up to 50th harmonic.
b) Current – up to 50th harmonic.

b. Minimum and Maximum Values:
1) Volts (L-L), Volts (L-N), Current (L, N, G), Watts, VARs, VA, power factor (Apparent and Displacement.)

2. Accuracy:
a. Revenue accuracy per ANSI C12.16 (0.5 percent) and C12.20 (0.5 percent).

3. Event Logging:
a. Automatic trigger setting per ITIC standard
b. Sequence of event logging with time/data

4. Display:
a. Door-mounted LCD

5. Power Supply: 120VAC

6. Communications:
a. Ethernet/IP

7. Onboard memory:
a. 4GB minimum.

8. Time synchronization:
a. Network time protocol (NTP)

9. Manufacturers:
a. Eaton PXM6000
b. Schneider ION7550
c. Or equal

2.12 SURGE PROTECTIVE DEVICES

A. Provide metal oxide varistor (MOV) surge protective devices (SPD) on each switchgear bus.

B. Modular parallel surge protective device (SPD) shall have use metal oxide varistors. A surge suppression path shall be provided for each mode, line to neutral, line to ground, and neutral to ground. Each surge suppression mode shall be individually fused and use circuitry with thermal cutouts to isolate the SPD and ensure shutdown in the event of the MOV damage during sustained overvoltages.

C. Features: SPD shall include the following:
1. High-energy parallel design for IEEE C62.41 and C62.45 category C
2. Duty cycle tested (ANSI C 62.41 C3, 10 kA 20 kV) minimum 5000 impulses.
3. EMI/RFI filtering up to -50 dB (100 kHz to 100 MHz)
4. Form C dry contacts
5. UL 1449
6. 5-year warranty

D. Surge Capacity: 250 kA minimum surge capacity per phase.

E. Unit Mounting: SPD shall be mounted in a 22-inch tall SWGR unit. The unit shall include:
   1. Molded case circuit breaker
   2. Plexiglass cover over the circuit breaker and SPD
   3. Disconnect
   4. Display on the door with the following:
      a. LCD screen with surge count
      b. Surge count reset button.
      c. LED for each phase indicating protection is functional.
      d. LED for each phase indicating replacement is required.
      e. Alarm with silence button

2.13 AUTOMATIC TRANSFER CONTROL

A. Provide an automatic transfer control system that operates the utility main breaker, the generator main breaker, and the tie breaker to ensure power is provided to the feeder breakers whenever the utiliy source is available.

   1. The normal configuration for these breakers will be with the utility main breaker closed, the generator main breaker open, and tie breaker open for service from the incoming utility power source.

   2. In the event of the loss of the incoming source, and after 30 seconds (programmable from 2 to 120 seconds), the main breaker on the lost source shall automatically open, a call to run command shall be sent to the generator, the generator main breaker shall close, and the tie breakers shall close.
   3. Provide a enable/disable function selector switch function that allows disabling of the transfer function with indication in all user interface screens that the transfer function is not enabled

B. The restoration sequence when power is restored on the lost source shall be open transition. The generator shall open and the main breaker on the restored source shall close. Initiation of the restoration sequence shall be automatic or manual selectable via the HMI interface to the automatic transfer controller.

C. The utility main breaker, the generator main breaker, and tie circuit breakers shall be interlocked to positively prevent all three (3) breakers from all being closed at any time. This shall be done via positive electrical interlocking. The interlocking shall be redundant with two (2) means of electrical interlocking: hard-wired interlocking and programmed logical interlocking in the automatic transfer controller.

D. The controls for this transfer scheme shall be provided with the switchgear and shall be powered from either incoming power source such that the controls are fully functional regardless of which incoming power source is available.

E. Adjustable time delays shall be included for timing functions for delay on initial transfer on power loss and for the delay on automatic restoration to a restored source.

F. Provide status monitoring for the following conditions:
   1. Power loss on Source 1 (Bus A).
   2. Power loss on Source 2 (Bus B).
   3. Indication that the breakers have transferred to the generator power source.
   4. Indication that transfer back to the restored power source will occur in X seconds.
   5. Indication that transfer back to the restored power source has been initiated.
   6. Indication that transfer back to the restored power source has been completed.
   7. Provide all line and load side potential transformers to monitor voltage as required for implementation of this scheme or include interface to the power monitors specified for this switchgear.
   8. Arc flash reduction selector switch engaged (Bus A).
   9. Arc flash reduction selector switch engaged (Bus B)

G. Power loss sensing shall include single phasing, and undervoltage and overvoltage conditions.

2.14 CONTROL POWER

A. Provide all control power required for the operation of the switchgear. Control power shall be internally derived from the power buses.

B. Separate and independent power supplies shall be provided for the A side and B side of the switchgear and the associated circuit breakers and control functions. Common control power required for common functions such as automatic transfer controls and the tie breaker shall be provided via control power sources capable of drawing power from either of the A side or B side power sources should one or the other not be available. Should the control power source malfunction, the protective trip functionality of the circuit breakers shall be available whenever the breaker is powered from the line side.

C. Provide local and HMI status indicating lights that control power is available for all control power sources (utility and generator).

2.15 UNINTERRUPTIBLE POWER SYSTEM (UPS)

A. Provide a switchgear mounted 120VAC UPS system for power of the automatic transfer controller PLC, power monitor communications to SCADA and local display.

B. UPS system shall be specifically for use within the switchgear. Provide dedicated space/compartment within switchgear for UPS and batteries.

C. UPS system shall provide communications to plant SCADA system and provide the following remote monitoring capabilities:
   1. Two methods of communication shall be supported.
      a. Form "C" relay contacts. Each status item shall have its own dedicated relay contact.
      b. Modbus TCP/IP.

2. Provide remote status for:
    a. Input Fail / On battery
    b. UPS On-Line
    c. Low Battery
    d. Load on Bypass

2.16 ACCESSORIES

A. Provide a traveling type circuit breaker lifter, rail-mounted on top of switchgear.

B. A remote racking and operation device shall be provided for operation of the circuit breakers from a distance. No modification of breaker, cell or door shall be necessary to use the device. Opening and closing electrically and manually operated devices shall be possible.

C. Test Set.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install switchgear in accordance with the manufacturer's requirements and recommendations and the submitted and approved anchorage design.

3.02 PROTECTIVE DEVICE SETTINGS

A. The protective devices shall be adjusted to the settings specified in the protective device coordination study in Section 26 05 74 prior to energizing the switchgear.

3.03 FIELD TESTS

A. Each switchgear breaker shall be tested in accordance with Section 26 08 00.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.01 DESCRIPTION

A. Three phase, four wire 208Y/120 or 480Y/277 volt, dead front, circuit breaker type panelboard with current rating of 600-amperes or less.

B. Single phase, three wire 120/240 volt, dead front, circuit breaker type panelboards with current rating of 400-amperes or less.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE	Institute of Electrical and Electronic Engineers
NEMA	National Electrical Manufacturing Association
NFPA 70	National Electrical Code (NEC)
UL 50	Cabinets and Boxes
UL 67	Underwriters Laboratories, Electric Panelboards
UL 489	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
UL 1449	Surge Suppression Devices

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
   1. Eaton / Cutler-Hammer:
      a. PRL1a and PRL3a
   2. General Electric:
      a. AQ and AD
   3. Siemens:
      a. S1, SE, and S3
   4. Square D:
      a. NQOD and NF
   5. or equal

2.02 ARRANGEMENT AND CONSTRUCTION

A. The front of the panel shall have concealed trim clamps and hinges. The locks shall be flush with cylinder tumbler-type with spring loaded door pulls. The fronts shall not be removable with doors in the locked position. Panelboard locks shall be keyed alike.

B. Gutter space shall be provided on all sides of the breaker assembly to neatly connect and arrange incoming wiring.

C. Panelboard shall be composed of individually mounted circuit breakers designed to be removable without disturbing other breakers.

D. A directory holder with clear plastic plate and metal frame shall be mounted on the inside of the door.

2.03 BUS

A. Bus shall be tin-plated copper and shall have current ratings as shown on the panelboard schedules, sized in accordance with UL 67. Ratings shall be determined by temperature rise test.

B. The minimum bus size shall be 100 amperes. Panel fault withstand rating shall be not less than the interrupting rating of the smallest circuit breaker in the panel. Series rating is prohibited.

C. Panelboards shall be provided with a separate ground bus and, where specified, with a full capacity neutral bus. The neutral bus shall be mounted on insulated stand-offs.

2.04 CIRCUIT BREAKERS

A. Circuit breakers shall be molded-case type provided for the current ratings and pole configurations specified on the panelboard schedule. Circuit breakers shall be bolt-on type. Circuit breakers shall be listed in accordance with UL 489 for the service specified. Load terminals of circuit breakers shall be solderless connectors.

B. Circuit breakers rated 120/208 volt and 120/240 volt alternating current shall have a minimum interrupting current rating of 18,000 amperes symmetrical at 240 volt AC.

C. Circuit breakers rated 277/480 volt alternating current shall have a minimum interrupting current rating of 25,000 amperes symmetrical at 480 volt or as specified on the panelboard schedule.

D. Provide circuit breakers with special features such as ground fault interrupting (GFI), heating air conditioning and refrigeration (HACR) rating, or locking capability as shown on the Drawings or Schedules.

2.05 FINISH

A. Panelboard cabinet shall be fabricated from hot-dip galvanized steel in accordance with UL 50. Panelboard fronts shall have a gray, baked enamel finish.

2.06 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of Section 26 05 00.

2.07 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's certification that bus bracing is capable of withstanding the specified short circuit condition.
   2. Operation and maintenance information as specified in Section 01 78 23.
   3. Quantity and rating of circuit breakers provided with each panelboard.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall type in the circuit description on the circuit directory as shown on the final record drawings or panelboard schedule.

B. Provide “Circuit Directory and Circuit Identification” in accordance with NEC 408.4. Each circuit shall be of sufficient detail to allow each circuit to be distinguished from other circuits. Circuit identification shall include load location and provide equipment or instrument Tag Number and Tag Description, where shown on the drawings.

3.02 TESTING

A. Panelboards shall be tested for proper operation and function.

3.03 SCHEDULE

A. Panelboards schedules as shown on the drawings.

END OF SECTION

SECTION 26 24 19

MOTOR-CONTROL CENTERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies freestanding, factory assembled 600 (480) volt Motor Control Centers (MCC) with digital power monitors to display the voltage and current load parameters.

B. Equipment List:
   1. MCCs specified herein shall be furnished by a single manufacturer.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/NEMA ICS 1	Industrial Control Systems: General Requirements
ANSI/NEMA ICS 18	Motor Control Centers
NFPA 79	Electrical Standards for Industrial Machinery
UL 845	Motor Control Centers

B. Codes And Standards:
   1. Motor Control Centers and all components shall be Underwriters Laboratory listed to UL 845 and shall conform to NEMA ICS-1 and ICS-18 standards.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Elementary connection and interconnection diagrams as required in paragraph 2.07, in accordance with NFPA 79 and/or NEMA ICS 18 Part 1 standards.

2. List of starters and feeder tap compartments indicating the size and type of circuit protection.
3. Interrupting, withstand, and continuous current rating of:
    a. Bus bars
    b. Feeder tap units
    c. Starter units
    d. Main incoming units
4. Nameplate schedule.
5. Dimensioned drawings showing conduit access locations.
6. Front view elevation with starter and component schedule.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Motor Control Centers shall be as manufactured by Allen Bradley, Square D, or equal.

2.02 SERVICE

A. Motor control centers shall be rated 480 volts, 60 Hertz, 3 phase, 3 wire (no neutral bus) as specified or indicated, suitable for operation at the specified voltages and short circuit capacities.

2.03 STRUCTURE AND CONSTRUCTION

A. Structure:
    1. Motor control centers shall be made of No. 14 gage steel minimum and, unless otherwise shown, each section shall be 90 inches high by 20 inches wide by 20 inches deep. The individual unit compartments shall be a minimum of 12 inches high.
    2. Each section shall have 72 inches for stacking starter units into the sections. Size NEMA 1 through 3 FVR and FVNR starter units shall be provided with an additional 6 inches of vertical space.
    3. The compartments shall have pan-type doors with a minimum of two quarter-turn hold-down latches; and neoprene gaskets.
    4. A full height vertical wireway, 4 inch wide minimum, but not less than 30 square inches in cross section, shall be provided for each vertical motor control center section. The wireway shall contain full height removable doors. Horizontal wireways shall be provided top and bottom, extending the length of motor control centers.
    5. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full length of the motor control center lineup. A removable lifting angle shall be mounted on top and shall extend the width of the motor control center lineup.

B. Construction:
   1. Motor control centers located indoors shall have NEMA 1, gasketed enclosures.
   2. Starter units, size 4 and smaller, and feeder tap units less than 225 amperes shall be drawout plug-in construction with hardened, tin-plated copper free-floating stabs, steel spring backups. The door shall have interference tabs which prevent door closure if unit is improperly installed.
   3. Units shall be latched in the position to assure proper bus contact. The unit disconnect device shall be interlocked to prevent removal or reinsertion of a unit when the disconnect is in the "ON" or "TRIPPED" positions.
   4. Fusible switch or circuit breaker disconnect operators shall be capable of accommodating three padlocks for locking in the "OPEN" position.
   5. Hardware for mounting future starter and feeder tap units shall be provided at compartments specified as "FUTURE."

C. Seismic Bracing:
   1. Motor control centers and related equipment shall conform to the seismic anchorage and bracing requirements of Section 01 73 23. As an additional minimum requirement, the Motor Control Centers shall be braced for the requirements of Section 01 73 23.

2.04 FINISH AND COLOR

A. The finish and color shall be in accordance with Section 26 05 00.

2.05 BUS

A. General:
   1. Bus shall be tin-plated copper with bolted connections between vertical and horizontal bus bars. Access for tightening these connections shall be from the front, without the need for tools on the rear of the connection. Insulated horizontal and vertical bus barriers shall be provided. Barriers shall be fabricated from high-strength, glass-filled polyester resin.
   2. The bus shall be braced to withstand a fault current of 65,000 amperes, RMS, symmetrical.

B. Horizontal Bus:
   1. Unless otherwise specified or shown, the main horizontal bus shall be rated a minimum 1600 amperes continuous.

C. Vertical Bus:
   1. Unless otherwise specified or shown, the vertical bus shall be insulated and rated a minimum 300 amperes continuous.

D. Neutral Bus:
   1. The neutral bus shall be provided and have the same rating as the main horizontal bus, where specified or shown.

E. Ground Bus:
   1. A 1/4-inch by 2-inch ground bus shall be provided the full length of the motor control center. Ground bus shall be located at the bottom of the motor control center. Provide a lug to terminate a bare 4/0 AWG copper ground conductors at each end of the ground bus.

2.06 WIRING

A. General:
   1. Motor control centers shall be provided with NEMA ICS 18 Class II, Type B wiring. All starter units shall have terminal blocks for control wiring. Terminal blocks shall be provided for power wiring for starters size 2 and smaller.
   2. Motor control centers shall be provided with all necessary interconnecting wiring and interlocking. When a MCC control section is specified on the drawings or schedules, wire directly to the relays or programmable controller's input/output modules as part of the interconnecting wiring.
   3. Provide elementary and connection diagrams for each starter unit and an interconnection diagram for the entire motor control center.

B. Power Wire:
   1. Power wire shall be copper 90 degrees C insulated, sized to suit load; minimum power wire size shall be No. 12 AWG copper stranded.

C. Control Wire:
   1. Control wire shall be No. 16 AWG stranded copper wire, rated 90 degrees C machine tool wiring (MTW) and UL listed for panel wiring.

D. Terminations and Cable Connections:
   1. Terminals:
      a. Control wiring shall be lugged with ring-tongue or locking spade crimp type terminals made from electrolytic copper, tin-plated.
   2. Cable Connectors:
      a. Cable connectors for use with stranded copper wire, sizes No. 8 AWG to 1000 kCmil shall be UL listed. Dished conical washers shall be used for each bolted connection. Connectors shall be reusable and shall be rated for use with copper conductors. Incoming line and outgoing feeder compartments shall be provided with crimp type lugs, 3M Company, Burndy Company, or equal.

E. Conductor Markers:
   1. Each power and control conductor shall be identified at each terminal to which it is connected. Conductors size No. 10 AWG or smaller shall have identification sleeves. Conductors No. 8 AWG and larger shall use cable markers of the locking tab type. Tabs shall be white plastic with conductor identification number permanently embossed.
   2. Adhesive strips are not acceptable.
   3. The letters and numbers that identify each wire shall be machine printed on sleeves with permanent black ink with figures 1/8 inch high. Sleeves shall be yellow or white tubing and sized to fit the conductor insulation. Shrink the sleeves with hot air after installation to fit the conductor.

2.07 MAIN AND FEEDER CIRCUIT PROTECTION

A. General:
   1. Main and feeder tap units shall consist of fused disconnect switches or circuit breakers, as specified or shown. Series ratings for overcurrent devices to meet specified short circuit withstand ratings is prohibited.

B. Circuit Breakers (Thermal Magnetic):
   1. Thermal-magnetic circuit breakers shall be molded case equipped with toggle type handle, quick-make, quick-break over center switching mechanism that is trip-free so that breaker cannot be held closed against short circuits and abnormal currents. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously. Minimum short circuit capacity shall be 65,000amperes symmetrical.

C. Circuit Breakers (Magnetic Only):
   1. Magnetic circuit breakers shall be molded-case equipped with toggle type handle, quick-make, quick-break over center switching mechanism that is trip-free so that breaker cannot be held closed against short circuits and abnormal currents. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously. Minimum short circuit capacity shall be 65,000 amperes symmetrical.

2.08 MOTOR STARTER UNITS

A. General:
   1. Motor starter units shall be combination type with contactor and fused disconnect switch, thermal magnetic circuit breaker, or motor circuit protector, and solid-state overload unit as indicated on the drawings or specified in the MCC schedule. The starter units shall have a minimum combination UL listing of 65,000 amperes RMS symmetrical or as indicated or specified in the schedule.

B. Motor Circuit Protectors:
   1. The molded case motor circuit protector (MCP) shall operate on the magnetic principle with a current sensing coil in each of the three poles to provide an instantaneous trip for short circuit protection. The trip setting shall be adjustable from 700 to 1300 percent of the motor full load amperes from the front of the MCP. The motor circuit protector shall be set at its lowest position at the factory.

C. Control Transformers:
   1. Each control transformer shall be rated 480/240-120V, single phase, 2-wires, 60 Hertz. The transformer shall be sized for the load it feeds but shall not be less than the minimum ratings as follows:

NEMA starter size	Minimum transformer volt-ampere rating
1	100
2	150
3	200
4	300

2. Each control transformer shall be provided with time-delay, slow-blow secondary fuse rated to interrupt 10,000 amperes short circuit at 250 volts AC. Two primary fuses rated to interrupt 200,000 amperes at 600 volts shall be provided on all starters.
3. Fuse holder for secondary fuse shall be drawout indicating type and mounted on the door of the compartment. Fuse holders for primary fuses shall be fuse clips with full barriers between fuses.

D. Contactors:
1. Unless otherwise specified or shown, contactors shall be full voltage, 3-pole, 600 volt AC, NEMA Size-1 minimum. Contacts shall be double break, silver-cadmium oxide, and weld resistant. Contacts shall be isolated to prevent arcing. Coils and magnets shall be capable of being removed or replaced without special tools. IEC contactors are prohibited.
2. Reversing, multispeed, and reduced voltage starters shall have additional contactors, overload relays, and auxiliary relays as required, and shall have mechanically interlocked contactor coils to prevent simultaneous engagement.

E. Transient Voltage Surge Suppressor:
1. Provide metal oxide varistor (MOV) surge protective device (SPD) integral within each motor control center that indicates the status and condition of the SPD, tested per NEMA LS-1, rated IEEE C3 Combined Wave of 20kV and 10kA with 200kAIC internal fusing and listed / labeled per UL 1449. Minimum surge rating: 160kA per phase.
2. Provide a factory selected transient surge suppressor rated for each motor starter and power contactor encapsulated in a small module and mounted directly to the starter or contactor coil.

F. Auxiliary Contacts:
1. Contactors shall be equipped with auxiliary contacts, rated 10 amperes at 120 volts AC. Refer to drawings for actual quantities required. As a minimum, each contactor shall be equipped with two normally open and two normally closed electrically isolated auxiliary contacts with the used and auxiliary contacts wired out to terminal blocks.

G. Overload Relay:
1. The solid-state overload relay shall protect the power wiring and motor from excessive overcurrents. The relay shall be ambient compensated and have adjustment from 90 to 110 percent of the normal rating.
2. The sensing element shall be adjustable Class 20 tripping time of 20-seconds at 600-percent of current setting. The faster overload trip Class 10 (10-seconds at 600-percent of current setting) and the longer overload trip Class 30 (30-seconds at 600-percent of current setting) shall be field set by the installer during the driven equipment startup with the overload settings that are required by the type of motor driven load.

H. Terminal Blocks:
1. Terminal blocks shall be screw type rated 600 volts; 20 amperes for control wiring and 30 amperes power wiring with starters Size 3 and larger shall terminate the power leads directly to the contactor.

2. The number of terminal blocks shall be specified on the drawings. Terminal blocks shall be provided with integral marking strips and shall be permanently marked with the conductor number as specified on the drawings. Internal wiring shall be connected on one side of the terminal block; outgoing conductors shall be connected to the other side.

2.09 MISCELLANEOUS

A. General:
   1. Control devices such as pushbuttons, selector switches, indicating lights and overload reset pushbuttons shall be mounted on the unit compartment door.
   2. The control devices shall comply with the requirements of Section 26 09 16.

B. Elapsed Time Indicator:
   1. Where shown or specified, the elapsed time indicator shall be as specified in Section 26 09 16. The indicator shall be mounted on the unit compartment door.

C. Nameplates:
   1. Nameplates shall be provided in accordance with the requirements of Section 26 05 00. Nameplates shall be provided for all cubicles and compartments and identify the load per NEC. A Nameplate shall be provided identifying the motor control center. Provide equipment tag numbers and descriptions as shown on the drawings.

2.10 SPACE HEATERS AND THERMOSTATS

A. Motor control centers located outdoors or in a corrosion rated area shall be provided with space heaters and thermostats to maintain the interior temperature at more than 45 degrees F. Space heaters and thermostats shall be rated 120 volts AC. Space heater shall be powered from a control power transformer.

2.11 DRY-TYPE TRANSFORMERS

A. Dry-type energy efficient power transformers shall meet the requirements of Section 26 22 00. The size and voltage shall be as specified.

2.12 ADJUSTABLE FREQUENCY DRIVES

A. AFDs mounted in motor control centers shall be flush mounted and shall meet the following requirements.
   1. AFD, ASD, VFD, VSD are interchangeable terms.
   2. Provide variable or constant torque PWM type drives for motors as indicated on the Drawings. MCC mounted AFD's shall not be applied for motors exceeding 60 horsepower. Include circuit breaker disconnecting means, 3-percent line reactors and cooling fans as required to dissipate the heat into the room.
   3. Provide a motor terminator to trim the reflected-wave voltage spike from reflected waves from the motor where indicated on the Drawings.
   4. Provide ratings as indicated.
   5. Provide microprocessor Operator Interface Station (OIS) on the AFD door.
   6. EMI/RFI shielding as required for products and wiring.

7. Provide current limiting fuses for short circuit protection.
8. Provide factory technician for setup, startup services, and training.
9. Data communication: None.
10. Provide four Form C relays with 5-ampere contacts for interlocks.
11. Provide four programmable relay outputs for on-off status, alarm, “Remote” mode.
12. Provide isolated 4-20madc analog input for speed control.
13. Provide isolated 4-20madc analog output for speed indication.
14. Provide a harmonics filter for the MCC bus. Meet IEEE-519 for voltage and current harmonics with Point-of-Common-Coupling at the MCC bus.

2.13 REDUCED VOLTAGE SOLID STATE STARTERS (RVSS)

A. RVSS mounted in motor control centers shall be flush mounted and shall meet the following requirements.
   1. Provide ratings as indicated and circuit breaker.
   2. Provide full-voltage operating contactor. Provide cooling fan and filter, as required.
   3. Provide EMI/RFI shielding as required for products and wiring.
   4. Provide current limiting fuses for short circuit protection, as required.
   5. Provide factory technician for setup, startup services, and training.
   6. Data communication: None.
   7. Provide [one] [two] [three][four] Form-C relays with 5-ampere contacts for interlocks.
   8. Provide selectable kick start and adjustable ramp up and ramp down speeds.
   9. Provide overload protection with selectable classes of 10, 15, 20, and 30 with three-phase current sensing, initially set for 20 and field adjusted as required for the application by the Factory Engineer.
   10. Provide the following selectable protection:
      a. Under-load
      b. Under-voltage
      c. Over-load
      d. Over-voltage
      e. Voltage Unbalance
      f. Excessive Starts Per Hour
      g. Phase Reversal
      h. Stall and Jam
   11. Provide microprocessor Operator Interface Station (OIS) on the SSS door and display as a minimum:
      a. Three-phase current
      b. Three-phase voltage
      c. Power in kW
      d. Power usage in kWh
      e. Power factor
      f. Elapsed time

12. Provide programmable relay outputs for:
    a. Fault alarm
    b. On-Off status
    c. Auto mode or Remote mode status
    d. Ready status
    e. Full-Speed-Bypass status

2.14 SPARE PARTS

A. One set consisting of the following spare parts shall be provided:
    1. 1--set each fuse size and type
    2. 10--indicating light bulbs

2.15 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
    1. Manufacturer's certification that the following items are capable of interrupting and/or withstanding the specified short circuit condition:
        a. Bus bar bracing
        b. Feeder tap units
        c. Starter units
    2. Operation and maintenance information as specified in Section 01 78 23.
    3. Dimensions and weights.
    4. Installation instructions.
    5. Manufacturer's product data.
    6. Manufacturer's certification and calculations confirming that the equipment complies with the seismic anchorage and bracing requirements of Section 01 73 23 and paragraph 2.03 Seismic Bracing.

PART 3 EXECUTION

3.01 GENERAL

A. The motor control centers shall be erected in accordance with the recommendations of the manufacturer and with the details specified herein.

B. Field wiring shall meet the requirements of Section 26 05 19-3.02.] Cables larger than No. 6 AWG which hang from their vertical connections shall be supported within 2 feet of the connection.

C. The solid-state overload relay settings shall be implemented by the Contractor with the settings selected based on the actual full load amperes of the motor connected to the starter and the requirements of the motor driven equipment. Refer to the manufacturer’s literature for setting the overload relays. Refer to the overload relay paragraph 2.09 Overload Relay for the setting options that available in the overload relay.

D. The motor circuit protectors shall be adjusted by the Contractor to the lowest setting not causing false tripping.

E. Install motor control centers level and plumb on 3-1/2-inch concrete housekeeping pads per the manufacturer's installation instruction.]

F. [Seismic anchorage shall be per Section 01 73 23.

3.02 FIELD TESTS

A. Motor control centers shall be tested in accordance with Section 26 08 00.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section specifies wiring devices consisting of receptacles, plugs, switches and appurtenances.

1.02 REFERENCES

A. This Section contains references to the following documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA WD-1	General Requirements for Wiring Devices
NFPA 70	National Electrical Code (NEC)

PART 2 PRODUCTS

2.01 GENERAL

A. Wiring devices shall be UL approved for the current and voltage specified and shall comply with NEMA WD-1. Devices shall contain provisions for back wiring and side wiring with captive binding screws.

B. Provide devices colored to conform to manufacturer's or industry standard for special use such as orange for isolated ground receptacles, blue for surge suppression receptacles, and red for emergency power receptacles. Unless shown otherwise on the Drawings or Schedules, normal use devices shall be brown, except those located in finished areas shall be ivory.

2.02 RECEPTACLES AND PLUGS

A. General:
   1. Receptacles shall be grounding type.

B. 120V Receptacles:
   1. Indoor, Clean Areas:
      a. Unless shown otherwise on the Drawings or Schedules, receptacles shall be duplex 20 amp, NEMA 5-20R, and shall accept NEMA 5-15P and 5-20P plugs. Where the manufacturer of cord connected equipment requires and isolated ground, a receptacle with isolated ground shall be provided.
         1) Manufactures: Hubbell 5362, 5362-AI or equal.
         2) Isolated ground receptacle manufactures: Hubbell IG-5362, Arrow-Hart IG5362, or equal.
   2. Outdoor, Process or Corrosive Areas:
      a. Receptacle shall be duplex, 20 ampere, NEMA 5-20R, and shall accept NEMA 5-15P and 5-20P plugs. Receptacle and plug shall be corrosion resistant, marine duty with yellow polycarbonate weatherproof lift covers that maintain weatherproofing during receptacle use.
         1) Manufacturers: Hubbell 53CM62/53CM21, 15W33W/O BOX, or equal.

C. 250V Receptacles:
   1. Receptacles shall be duplex 15 amp, NEMA 6-15R, and shall accept NEMA 6-15P plug caps. Receptacles shall be Hubbell 5662, Arrow Hart 5662, or equal. Plug caps shall be Hubbell 5666-C, Arrow-Hart 6866, or equal.

D. Plug Caps:
   1. Male plug caps for 120 volt and 250 volt receptacles shall be of the cord grip armored type with heavy phenolic housing, of the same manufacture as the receptacle. Plug caps shall be rated 15 amps. One plug cap shall be provided for every four receptacles furnished, with a minimum of two plug caps being provided. Plug caps shall be delivered to the Construction Manager.

E. Three Phase Receptacles and Plugs:
   1. Receptacles shall be suitable for 480 volt, 3-phase, 4-wire service, with ampere ratings as specified. Receptacles and plugs shall be designed so that the grounding pole is permanently connected to the housing. The grounding pole shall make contact before the line poles are engaged when the plug is connected to the receptacle housing. The plug sleeve shall also make contact with the receptacle housing before the line and load poles make contact. Receptacles shall be provided complete with cast back box, angle adapter, gaskets, and a gasketed screw-type, weathertight cap with chain fastener. Each receptacle shall be provided with one plug.
   2. Manufactures:
      a. Crouse-Hinds "Arktite," Appleton "Powertite," or equal.

F. Receptacles for Hazardous Areas:
   1. Receptacles for use in hazardous areas shall be rated in accordance with NEC for the area in which they are to be located and shall be factory sealed. Receptacles shall be designed so the plug must be inserted and turned before load is energized. Receptacles shall be provided with mounting box, sealing chamber, and compatible plug. Voltage and current ratings shall be as 120 Vac, 20-ampere.
   2. Manufactures:
      a. Appleton "U-Line," Crouse-Hinds "Ark-Gard 2," or equal.

2.03 SWITCHES

A. General Purpose (Indoor, Clean Areas):
   1. General purpose switches shall be quiet AC type, specification grade, back and side wired, and shall be provided in accordance with rated capacities as required or as indicated on Drawings or Schedules. Switches shall match receptacles in color.
   2. Manufactures:
      a. General Electric, Hubbell, or Construction Manager accepted substitute , as follows:

	15A, 120-277V		20A, 120-277V	
	G.E. Co.	Hubbell	G.E. Co.	Hubbell
Single:	PS 15AC1	HBL1201	PS 20AC1	HBL1221
Three-way:z	PS 15AC3	HBL1203	PS 20AC3	HBL1223
Four-way:	PS 15AC4	HBL1204	PS 20AC4	HBL1224
SPST momentary:	# 7842	--	--	--
Three position center off momentary:	# 1250	HBL1556	--	HBL1557

B. Switches for Outdoor and Corrosive Areas:
   1. Switches shall be 20-ampere with weatherproof/ corrosion resistant neoprene plate. Switches shall be mounted in "FS" type copper-free aluminum or PVC mounting boxes.
   2. Manufactures:
      a. Hubbell or Arrow-Hart as follows:

	Hubbell with 17CM50 plate	Arrow-Hart with 2881 plate
Single pole	1281	2991
Double pole	1282	2992
3-way	1283	2993
4-way	1284	2994

2.04 DEVICE PLATES

A. Device plates shall be provided with switches. In non-corrosive indoor areas, receptacle device plates shall be made of sheet steel, zinc electroplated with chrome finish as manufactured by Crouse-Hinds, Appleton, or equal.

B. Device plates in corrosive or outdoor areas shall be corrosion-resistant/marine-duty type. Device plates for explosion-proof equipment shall be factory provided with the equipment.

C. Device plates shall be provided with engraved laminated phenolic nameplates with 1/8-inch white characters on black background.

D. Nameplates for switches shall identify panel and circuit number and area served. Nameplates for receptacles shall identify circuit and voltage if other than 120 volts, single phase.

2.05 PLUG STRIPS

A. Plug strips shall be manufactured of sheet steel with the receptacles mounted on the front cover. The front cover shall be removable.

B. Plug strips for office and laboratory areas shall have single 3 wire, 20 ampere grounding type receptacles mounted along the strip on a single circuit.

C. Plug strips for work benches in shop and laboratory areas shall have 3 wire, 20 ampere grounding type duplex receptacles mounted along the strip on the circuits specified. Sufficient space shall be provided behind the receptacles for ten No. 12 AWG conductors in accordance with the NEC space rules.
   1. Manufacture of plug strips:
      a. Plugmold, or equal.

2.06 PRODUCT DATA

A. In accordance with Section 01 33 00, the Contractor shall provide catalog cuts for all materials provided under this section.

PART 3 EXECUTION

3.01 INSTALLATION

A. Boxes shall be independently supported by galvanized brackets, expansion bolts, toggle bolts, or machine or wood screws as appropriate. Wooden plugs inserted in masonry or concrete shall not be used as a base to secure boxes, nor shall welding or brazing be used for attachment.

B. Receptacles and switches installed in sheet steel boxes shall be flush mounted. Flush mounted receptacles shall be located 18 inches above the floor unless otherwise indicated. Switch boxes shall be mounted 48 inches above the floor. Receptacles installed in cast device boxes shall be located 48 inches above the floor.

C. Wiring devices shall be tested for correct connections.

END OF SECTION

SECTION 26 28 16.16

ENCLOSED SWITCHES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies:
   1. 3-Pole Enclosed Disconnect Switches: Straight-Blade
   2. 3-Pole Enclosed Disconnect Switches: Rotary
   3. Single Phase Enclosed Disconnect Switches

B. Request clarification where conflicts occur with this section and other sections in Divisions 23, 26, 40, 43, and 46.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids.

C. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

D. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA FU-1	Low Voltage Cartridge Fuses
NEMA KS-1	Enclosed and Miscellaneous Distribution Equipment Switches (600 V Max.)
UL 98	Enclosed and Dead-Front Switches
UL 250	Enclosures for Electrical Equipment

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      a. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
      b. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
      c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Nameplate legend with engraving and sizes.
   3. Manufacturer's catalog data for all material provided under this section shall be assembled in a folder with each page clearly marked with the item model number and reference number to the specification.
   4. Operation and maintenance data as specified in Section 01 78 23 including approved submittal manufacturer’s catalog data, as-built drawings, and instructions for all configurable or programmable components.

PART 2 PRODUCTS

2.01 3-POLE ENCLOSED SWITCH ASSEMBLIES: STRAIGHT-BLADE

A. Manufacturers:
   1. ABB TH Series
   2. Eaton DH Series
   3. Schneider Electric H Series
   4. Or equal

B. Standards:
   1. UL 98 listed
   2. NEMA KS-1 compliant

C. Features:
   1. Enclosure:
      a. Dead-front design with hinged door
      b. Environmental Ratings:
         1) Indoor enclosures: UL Type 12
         2) Outdoor or corrosive areas: UL Type 4X 316 stainless steel
         3) Hazardous classified areas: UL type suitable for the class, division, and group of the hazardous classified area into which the switch will be installed.
      c. Finish Color: ANSI 61 gray
   2. Switch Mechanism:
      a. Ratings:
         1) Voltage: 600VAC
         2) Amps: As indicated on the Drawings
         3) Poles: 3
      b. Quick-make, quick-break type
      c. Straight-blade switch with vertical up/down handle.
      d. Line terminal shields
   3. Fuses:
      a. Where a disconnect switch is indicated as fused on the Drawings, provide Class R current-limiting fuses, conforming to NEMA FU-1, rated minimum 100kAIC.
   4. Interlocks:
      a. Preventing door from being opened when the switch is in the "ON" position. With defeat mechanism on switch exterior.
   5. Padlocking Provisions:
      a. Suitable to install padlock with 3/8" shank to lock the switch in the OFF position.
      b. Suitable to install padlock with 3/8" shank to lock the hinged door in the CLOSED position.
   6. Equipment Ground Lug:
      a. With terminations for incoming and outoing equipment ground cables.
      b. Bonded to switch enclosure.
   7. [Auxilary Contact(s):
      a. Where indicated on the Drawings (Control Schematics), provide auxiliary contacts in the Disconnect switch with a break-before-break configuration where the auxiliary contact opens before the main power contacts open.]

2.02 3-POLE ENCLOSED SWITCH ASSEMBLIES: ROTARY

A. Manufacturers:
   1. Eaton ER Series
   2. Leviton LDS Series
   3. Hubbell HBLDS3 Series
   4. Mennekes DS Series
   5. Or equal

B. Standards:
   1. UL 98 listed
   2. NEMA KS-1 compliant

C. Features:
   1. Enclosure:
      a. Dead-front design with cover secured by 4 stainless steel screws
      b. Environmental Ratings:
         1) Indoor enclosures: UL Type 12
         2) Outdoor or corrosive areas: UL Type 4X 316 stainless steel
         3) Hazardous classified areas: UL type suitable for the class, division, and group of the hazardous classified area into which the switch will be installed.
      c. Finish Color: ANSI 61 gray
   2. Switch Mechanism:
      a. Ratings:
         1) Voltage: 600VAC
         2) Amps: As indicated on the Drawings
         3) Poles: 3
      b. Quick-make, quick-break type
      c. Rotary type with 90 degree travel operating handle
   3. Fuses:
      a. Where a disconnect switch is indicated as fused on the Drawings, provide Class J current-limiting fuses, conforming to NEMA FU-1, rated minimum 100kAIC.
   4. Interlocks:
      a. Preventing door from being opened when the switch is in the “ON” position.
   5. Padlocking Provisions:
      a. Suitable to install padlock with 3/8” shank to lock the switch in the OFF position.
   6. Equipment Ground Lug:
      a. With terminations for incoming and outoing equipment ground cables.

2.03 SINGLE-PHASE ENCLOSED SWITCH ASSEMBLIES

A. Manufacturers:
   1. Non-Classified Locations:
      a. Bryant 30102D
      b. Greenheck N1TS4
      c. Hubbell HBL13 Series
      d. Or equal
   2. Hazardous Classified Locations:
      a. Appleton EDS series
      b. Or Equal

B. Features:
   1. Enclosure:
      a. Environmental Ratings:
         1) Indoor enclosures: UL Type 3 or 12
         2) Outdoor or corrosive areas: UL Type 4X 316 stainless steel
         3) Hazardous classified areas: UL type suitable for the class, division, and group of the hazardous classified area into which the switch will be installed.
      b. Finish Color: ANSI 61 gray
   2. Switch Mechanism:
      a. Ratings:
         1) Voltage: 240VAC
         2) Amps: 30A minimum
         3) Poles: 1 or 2
      b. Quick-make, quick-break type
      c. Toggle switch or rotary type
      d. Switch disconnecting motor circuits:
         1) Motor rated for the horsepower of the connected load
   3. Non-fused
   4. Interlocks:
      a. Preventing door from being opened when the switch is in the “ON” position.
   5. Padlocking Provisions:
      a. Suitable to install padlock with 3/8” shank to lock the switch in the OFF position.

2.04 NAMEPLATES

A. Provide nameplates for all enclosed switches in accordance with the requirements of Section 26 05 00-2.04.

2.05 ACCESSORIES:

A. Provide the following:
   1. One fuse puller for each class of fuse installed up to 200A.

2.06 SPARE PARTS

A. Provide the following:
   1. One set (3) spare fuses for each type and amp rating provided.

PART 3 EXECUTION

3.01 APPLICATION

A. Provide rotary type disconnects switches for valve actuators and HVAC equipment only

3.02 INSTALLATION

A. Install switch assemblies 60 inches above the floor, ground, or slab to center of operating handle.

B. Install fuses for fusible switches.

C. Install nameplates with the equipment tag number, equipment description, and power source as indicated on the drawings. Labeling requirement shall be met by the electrical contractor regardless of which trade has provided and/or installed the disconnect switch.

D. Provide adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

E. Perform acceptance testing of enclosed switches in accordance with Section 26 08 00.

END OF SECTION

SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies individual motor starters and motor controllers installed in enclosures other than motor control centers. Refer to drawings for product, device, and circuit requirements.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids.

C. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

D. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA ICS 1	General Standards For Industrial Control and Systems
NEMA 250	Enclosures for Electrical Equipment (1000-Volt Maximum)

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:
   1. Verification of fault withstand ratings, as applicable, and interrupting ratings
   2. The bill-of-material, schematic diagram, and wiring diagrams

PART 2 PRODUCTS

2.01 ENCLOSURE

A. The door to the motor starter enclosure shall be interlocked with an externally operated disconnect handle. Disconnect handle shall be arranged to indicate disconnect position. The disconnect operator handle shall have provisions to accept up to three 3/8-inch shackle padlocks to lock the disconnect in the open position.

B. Enclosures shall be:
   1. NEMA 12 for indoor areas.
   2. NEMA 3R for outdoor areas.
   3. NEMA 4X [stainless steel, or non-metallic in chlorine storage areas]
   4. NEMA 7 cast metal for hazardous areas.

2.02 MOTOR BRANCH CIRCUIT PROTECTION

A. General:
   1. Motor branch circuit protection shall be provided by fused disconnect switches or molded case motor circuit protectors as specified or as indicated.

B. Fused Disconnect Switches:
   1. Fused disconnect switches shall be provided with visible knife blades, shielded line terminals and quick-make, quick-break switch operator. Fuse clips shall be Class R rejection type and sized for UL Class RK, one-time, time-delay fuses. Fuse assembly shall have a minimum short circuit capacity of 50,000 amps symmetrical.

C. Molded Case Motor Circuit Protectors:
   1. The motor circuit protector (MCP) type molded case circuit breaker shall only be used as a part of a combination motor starter.
   2. The MCP shall operate on the magnetic principle with a current sensing coil in each of the three poles to provide an instantaneous trip for short circuit protection. The trip setting shall be adjustable over a range of 700 to 1300 percent of the full load current of the motor served and shall be adjustable from the front of the breaker.
   3. The MCP circuit breaker shall be rated to interrupt [42,000] ampere symmetrical when used in conjunction with an individual motor starter.

2.03 MOTOR STARTERS

A. The basic full voltage, non-reversing motor starter (FVNR) shall consist of a 3 pole, 600 volt AC contactor, transient surge suppressor, and solid-state overload relay, NEMA Size-1 minimum. Reversing (FVR) and multispeed (2S2W) starters shall have additional contactors, overload relays and auxiliary relays as required for the specified functions.

B. The contactors shall comply with NEMA ICS and NEMA rated for the horsepower as specified.

C. Overload relays shall be adjustable solid-state with protection for each of the poles. An overload condition shall cause the overload relay to latch in the open position. Reset shall be accomplished with a reset button located on the unit door exterior. Trip setting shall be adjustable from 85 to 115 percent of rating. Provide [1] [2] Form C 2-ampere auxiliary contact for remote monitoring of the overload alarm condition.

2.04 SOLID STATE STARTERS

A. The solid state reduced voltage motor starter shall consist of a self-contained unit for the control of 3-pole, 460-volt, 60-Hertz electric motors. The starter shall use solid-state components to limit current during motor starting and stopping. The starter shall include built-in bypass contacts operating closed when the motor is running at speed.

B. Controls shall permit selection among soft-start with selectable kickstart, current limiting with starting that is programmable 50 to 600 percent of full load current and field set as required. Full voltage start with ramp time less than 0.25 second, dual ramp start, or a start profile designed to reduce fluid surges when starting pumps. Controls shall permit field selection among ramp to stop, coast to stop, or stop profile designed for use with pumps.

C. Provide an alphanumeric, backlit LCD display. Example: four-line 16-character, for controller set-up, diagnostics, status and monitoring. Provide a keypad for parameter adjustment.

D. Provide motor overload protection with selectable trip classes of 10, 15, 20 and 30 utilizing three-phase current sensing, initially field set at 20 and field adjusted as required for the application by the Factory Engineer.

E. Provide a minimum of four 2-ampere, 240 Vac rated auxiliary contacts for customer use. Configure output contacts for:
   1. “Auto-Mode” status, “Ready” status, “Full-speed-Bypass” status, and “Fault” alarm. Provide for remote start command. Provide for remote stop command.

F. Provide the following monitoring functions indicated through the LCD display:
   1. Three-phase current
   2. Three-phase voltage
   3. Power in kW
   4. Power usage in kWh
   5. Power factor
   6. Elapsed time.

G. Provided as standard:
   1. Pre-start line fault alarm
   2. Running line fault advising power loss
   3. Shorted or missing load connection
   4. Pre-start power loss with phase indication
   5. Over-temperature
   6. Fault alarm with phase problem indication.

H. Provide the following defeatable protection as standard:
   1. Under-load
   2. Under-voltage
   3. Over-load
   4. Over-voltage

5. Voltage Unbalance
6. Excessive Starts Per Hour
7. Phase Reversal
8. Stall
9. Jam.

I. When fault conditions are detected, the controller shall inhibit starting or shut down. Fault diagnostics shall be indicated in descriptive text on the LCD display. The exclusive use of fault codes is unacceptable. Provide an auxiliary contact that is programmable for fault indication.

J. Manufacture and model:
1. ABB
2. Allen-Bradley Bulletin 150 SMC Flex
3. GE
4. Eaton - Cutler Hammer
5. Siemens
6. Square D
7. or equal

2.05 TERMINAL BLOCKS

A. Terminal blocks shall be heavy duty, rated at 20 amperes, 600 volts, and shall contain integral marking strips.

B. Terminal blocks shall be provided for external control connections. Spare terminals shall be provided as specified. Terminals shall be permanently identified with the numbers specified.

2.06 CONTROL DEVICES

A. Combination starters shall be provided with door-mounted control devices as shown on the diagrams. Control devices shall be as specified in Section 26 09 16.

2.07 SURGE PROTECTION DEVICE

A. Surge protection devices shall be provided in each starter. Suppressors shall be encapsulated, three component, solid-state circuit, in a module suitable for mounting directly to the starter coil. Additional space for suppressors shall not be required. Suppressors shall be rated 120 volts AC/DC.

2.08 CONTROL CIRCUIT TRANSFORMERS

A. Each combination motor control unit shall be provided with a control circuit transformer rated for 480 x 240-120V, single phase, 60 Hertz. Unless otherwise specified, transformers shall have a minimum volt-ampere rating as follows:

Starter	CPT Minimum Volt-Ampere Rating
Size 1	100
Size 2	150
Size 3	200
Size 4	300

B. The transformer size shall be increased if the devices applied will cause a control transformer overload or secondary terminal voltage to drop to or below 95 percent of rated secondary control voltage when rated primary voltage is applied. Each control transformer shall be mounted within the enclosure along with its associated circuit breaker and starter.

2.09 CONTROL CIRCUIT FUSING

A. Two primary fuses, rated to interrupt 200,000 amperes at 600 volts, shall be provided on all motor starters.

B. Each control circuit transformer shall be provided with one control circuit secondary fuse. The secondary fuse shall have an interrupting rating of 10,000 amperes at 250 volts. The secondary fuse shall be sized at 125 percent of full load current. Fuses shall have time delay characteristics as required to prevent false tripping due to coil in-rush currents.

C. Fuse holders shall be lamp indicating type for blown fuse indication and shall contain neon lamp, clear transparent knob, and solder terminals.

2.10 WIRING

A. Conductors shall be 90-degree C switchboard type. Conductors shall be identified with tag numbers as specified in Section 26 05 00.

2.11 MANUAL STARTERS

A. Manual starters shall comprise a horsepower rated quick-make, quick-break, toggle mechanism together with overloads in all phase conductors.

2.12 ARC FLASH MITIGATION METHODS

A. The following arc flash and mitigation method requirements shall apply. Refer to specification section 26 05 74, NFPA-70 (NEC) for arc mitigation requirements, and NFPA-70E (Standard for Electrical Safety in the Workplace) for equipment labeling requirements.

B. Equipment Labels:
   1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.

C. Hinged Doors:
   1. Power distribution equipment shall have hinged rear doors where back access is shown.

D. [Remote Racking Devices:
   1. Power distribution equipment shall have remote racking devices for Operators to insert or remove rack-mounted breakers, rack-mounted devices, or auxiliary equipment drawers into the associated equipment location. [Provide one remote racking device for each IPA provided.]]

E. Insulated Power Bus and Insulated Cable Boots:
   1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
   2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.

F. [View Windows for Monitoring:
   1. Provide protected view windows into cabinets that allow infra-red analyzers, monitors, or cameras to monitor hot temperature for unusual heat generated by deteriorating connections. The view windows shall have a method to move the window protector and hold-in-place during the monitoring operation.]

G. [Power and Control Equipment Separation-for purpose of arc flash rating:
   1. Provide separation between power equipment and controls within an enclosure, cabinet, or panel by the uses of barriers, separate access doors, or by other means.
   2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.]

H. [Automatic Shutters:
   1. Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.]

2.13 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of 26 05 00.

2.14 SPARE PARTS

A. The following spare parts shall be provided:

2.15 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:
   1. Operating and maintenance as specified in Section 01 78 23.

2. Manufacturer's catalog data for all material provided under this section. The catalog data shall be assembled in a folder with each page clearly marked with the item and reference number to the specification.
3. MCP and solid-state overload rating selection data.
4. Product calibration and setup information.
5. A copy of the electrical diagrams in a plastic folder in the units.

PART 3 EXECUTION

3.01 DEVICE CALIBRATION AND TESTING

A. The Contractor shall size the overload relay heater elements or adjust the solid-state overload device to the actual nameplate full load amperes of the motor connected to the starter.

B. The Contractor shall adjust motor circuit protector to the lowest setting not causing false tripping.

C. The Contractor shall record the settings on each motor controller and record the settings as part of the Record As-Built drawing submittal.

3.02 MOUNTING HEIGHT

A. The Contractor shall mount local motor starters at 48 inches above the floor.

3.03 TESTING

A. Local motor starters and circuits shall be tested in accordance with Section 26 08 00.

END OF SECTION

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SECTION 26 29 23

VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies 480 Vac rated adjustable frequency drive motor controller systems using insulated gate bipolar transistors (IGBT) for pulse width modulation technology (PWM).
2. The AFDs specified in this section shall be the product of a single vendor and mounted in the specified cabinet enclosure.
3. The terms AFD (adjustable frequency drive), ASD (adjustable speed drive), VFD (variable frequency drive), and VSD (variable speed drive) are interchangeable for the purposes of this specification.
4. Refer to the drawings for control and monitoring requirements including special interlocking requirements. Refer to the Control Section 40 61 96 for the control description for the AFD system.

B. System Requirements:

1. The AFD system shall convert 460 volt, 60-Hertz nominal input to a suitable voltage and frequency to cause a premium efficient, inverter duty, squirrel-cage induction motor to run at a speed proportional to an external input analog 4 to 20 ma dc or digital input command as specified for the required AFD speed range.
2. The AFD system shall include rectifier units, inverter units, control circuitry, protective equipment, input line reactors and output load reactors and other filters and accessories as necessary to provide the specified functions to meet voltage and current harmonics at the specified point of common connection and to mitigate the motor reflected voltage wave. Unless otherwise specified, the point of common connection for AFDs shall be the 480 distribution bus (motor control center, distribution panel, etc.) immediately upstream of the AFD.
3. The AFD system torque requirement shall match the pump torque requirement. Verify the pump type and select variable torque (VT) or constant torque (CT) as specified in the AFD Schedule. Select 6-Pulse units for small pump motors and 18-Pulse units for large pump motors.

C. AFD Schedule:

Equipment Name & Tag Number	Drive Number	Drive Horse Power	Drive Speed Range	Driven Equipment Specification	AFD Type	AFD Enclosure & Mounting	Distance (ft) from AFD to Driven Equipment Motor
71-P-00010	71-VFD-00010	100	900-1800	43 23 62	18P	NEMA-1 Gasketed, Floor Mount	75
71-P-00020	71-VFD-00020	100	900-1800	43 23 62	18P	NEMA-1 Gasketed, Floor Mount	75
71-P-00030	71-VFD-00030	100	900-1800	43 23 62	18P	NEMA-1 Gasketed, Floor Mount	75

D. Environmental Conditions:
   1. Ambient conditions are specified in Section 01 11 80.

E. Seismic:
   1. Freestanding AFDs shall be braced per Section 01 73 23.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 519	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts
NEMA ICS 6	Industrial Control and Systems: Enclosures
NEMA ICS 7	Industrial Control and Systems: Adjustable-Speed Drives
NEMA ICS 7.1	Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems
NFPA 70	National Electrical Code (NEC)
UL Standard 508	Industrial Control Equipment

B. Industry Standards:
   1. The AFD shall be UL 508 listed and shall conform to the requirements specified in NEMA ICS 2, 6, 7 and 7.1.

C. Unit Responsibility:
   1. The Contractor shall assign unit responsibility for the adjustable frequency drives in this section as specified in Section 43 05 11-1.02 Unit Responsibility. The Contractor shall submit letters of certification with the shop drawings from the AFD manufacturer, the motor manufacturer, and the driven equipment manufacturer stating that they have reviewed each application and that the combination will satisfy the application duties required, for the actual motor sizes required, regardless of deviations from the scheduled "nominal horsepower."

1.03 PRODUCT HANDLING

A. AFD units shall be shipped in air-cushion vans to ensure against shipping damage and packed in suitable protective containers. The units shall be inspected upon receipt for damage.

1.04 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   2. Catalog and technical data including outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.
   3. Schematic diagrams and wiring connection diagram showing functions and identification of terminals.
   4. Voltage and current Total Harmonic Distortion (THD) calculations with line reactors or filter design to mitigate harmonics to meet IEEE-519, if applicable.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed that named manufacturers’ standard equipment or products will comply with the requirements of this Section. AFDs shall be installed in the custom enclosures as specified and Candidate manufacturers include:
   1. ABB ACQ-580
   2. Toshiba Series:
      a. W7 18-Pulse for centrifugal fan and pump motors
      b. G7 18-Pulse for slow speed and high-torque motors
   3. Cutler-Hammer SV9000
   4. General Electric AF-300
   5. Siemens Model 6SE32
   6. Square D Altivar Series

7. Siemens-Robicon
8. Allen Bradley
9. Or equal

2.02 ENCLOSURES

A. Provide AFD in NEMA enclosures with fan cooling and conformal coating protection on circuit boards for corrosive atmosphere protection.
   1. General:
      a. Provide enclosures with AFDs and custom control as required for the project and as indicated on the drawings. Each drive shall be designed for stand-alone operation and multiple drives shall not utilize shared components. Review the project site location, elevation, temperature, humidity, plant atmosphere, and load current-torque requirements to size the AFD and its associated enclosure with requirements specified herein and the control and monitoring devices and interlocks as indicated.
      b. Enclosures shall be designed for indoor service. Each AFD system shall be mounted in a NEMA 250 internally force ventilated enclosure with UL approved Class 1 filters on ventilation openings. Enclosures shall be fabricated from 12-gage minimum thickness sheet steel with an interior frame or formed to provide a rigid structure.
      c. Provide enclosure size to allow entry of power source and motor load cables as indicated on the drawings. Submit drawing of the source and load power cable location within the enclosure and indicated barriers from control and instrument wiring.
      d. Door width shall not exceed 30 inches and shall be hung on removable-pin hinges, with three-point latch hardware, and handle latch for 3/8-inch-shackle padlock.
   2. Finish and Coatings:
      a. AFD systems enclosures shall be finished with corrosion protection coatings inside and outside for hydrogen sulfide atmospheres. The electrical and electronic assemblies shall have conformal coatings.

2.03 AFD ASSEMBLIES

A. General:
   1. AFDs shall include the following assemblies:
      a. Power disconnect using a thermal magnetic circuit breaker or fused disconnect sized for the specific application by the manufacturer.
      b. Line input harmonic filter, as required, for harmonic mitigation.
      c. A load reactor for dV/dT mitigation or motor terminator units for addressing dv/dt effects at the motor
      d. Rectifier, direct current bus filter, and inverter.
      e. Control circuitry interface with Operator Interface Unit
      f. Output protection including phase overload

B. AFD Features:
   1. Provided with the following features:
      a. Fused control circuit transformer and microprocessor for system logic sequencing functions. Provide fuses with blown fuse indicator lamps.
      b. Accept 4 to 20 mAdc] [digital command input speed reference signal.
      c. A 4 to 20 mAdc output signal proportional to inverter output frequency for the speed range specified.
      d. Adjustable minimum/maximum frequency limits:
         1) Minimum frequency shall be adjustable from 6 to 40 Hertz.
         2) Maximum frequency shall be adjustable from 48 to 90 Hertz.
      e. Adjustable and independent timed linear acceleration and deceleration functions, adjustable from 6 to 20 seconds.
      f. Current limiting.
      g. Automatic restart.
      h. Control Wiring:
         1) 600 volt stranded copper
         2) 90 degrees C color-coded insulation
         3) No. 16 AWG
      i. Wiring Identification and Termination:
         1) Crimp type wire lugs with sleeve type markers at each termination point and numbered terminal blocks for external connections.
      j. Electrically isolated discrete output contacts for ready, running, remote mode status and trouble alarm.
      k. Conformal coated terminal blocks for control and signal wires entering and leaving the controller.
      l. Control Power:
         1) Provide a 120 Vac, triple fused, control power transformer for cooling fans and external control circuits when required. Control circuits shall be isolated from power circuits by distance and by insulated barriers.
      m. Provide 120 Vac or 24 Vdc as required for Operator Interface Unit.

C. Functional Requirements:
   1. Supply Power:
      a. Operate continuously with supply power of 480 volts plus or minus 10 percent, 60 Hertz plus or minus 3 percent and remain on line and operate without damage to the AFD or connected load during a supply power under-voltage variation to the drive up to 85% of its nominal value for 30 milliseconds at full load.
   2. Load:
      a. Capable of driving the specified maximum motor load continuously and under the following conditions:
         1) Deliver 110 percent of the specified load for up to 60 seconds in variable torque applications.
         2) Deliver 150 percent of the specified load for up to 60 seconds in constant torque applications.

3. Efficiency:
    a. Not less than 95 percent at 60 Hertz output driving the specified maximum load at rated torque and speed at 40 degrees C ambient based on measured input power versus output power with all specified components in the system.
4. Frequency and Voltage Regulation:
    a. Output frequency regulated to within 0.6 Hertz of the signal/output frequency relationship. Output voltage regulated to within 1.0 percent to produce minimum motor heating at any operating frequency within the specified range.
5. Frequency Range:
    a. AFD shall be capable of continuous operation with the specified load at any frequency between 6 and 60 Hertz unless noted otherwise.
6. Space and AFD Access:
    a. Enclosure size shall not exceed the size allotments specified on the drawings nor shall any portion of the AFD system exceed a height of 90 inches.
    b. Front accessible only and shall not require rear access.
    c. Mount against the wall without any clearance for ventilation or other purposes.
    d. Submit AFD in the enclosure drawing with the detail of front door and the internal arrangement, including the feeder and motor cables, and the control cables, and the instrument cable location and terminations.
7. Ambient Noise:
    a. Free field noise generated shall not exceed 85 dBA at 3 feet out from any point on the AFD enclosure under any normal operating condition.
8. Motor Coordination:
    a. AFDs shall be configured as required to maintain output voltage peaks at the connected motor windings from reaching levels damaging to the motor insulation. Provide protection integral to the AFD or as protective hardware to be installed at the motors.
        1) Where motor terminator units are provided, they shall be rated for the environment in which they are located. Motor terminator units shall be:
            a) Allen Bradley 1204 Motor Terminator for AFD with the maximum carrier frequency of 6 kilohertz,
            b) Cutler Hammer Reflected Wave Trap (RWT) with the maximum carrier frequency of 12 kilohertz,
            c) Or Equal product

D. Protection and Annunciation:
1. Overcurrent Protection:
    a. Electronic current limit at 150 percent of motor nameplate current and provide motor running overcurrent protection in compliance with NFPA 70.
2. Short Circuit Protection:
    a. Protected against load faults: bolted faults, phase to phase or phase to ground shall not damage the unit. Fault protection based on a power source short circuit capacity of 65,000 amperes RMS symmetrical at the AFD power input terminals with impedance or current limiting device provided.
3. Line Voltage:
    a. Protected against high and low line voltage on one or more phases.

4. Internal Faults:
    a. Internal fault monitoring system to detect malfunctions to protect from transient and sustained faults and to limit damage that may be caused.
5. Motor Over Temperature:
    a. Interface to motor over temperature device 2-ampere output contact to shut down and alarm if the motor becomes overheated.
6. Fault Alarm:
    a. Indicates the cause of any shutdown visible on the AFD keypad/display without opening the AFD enclosure. As a minimum, the following faults shall be alarmed:
        1) Motor over-temperature
        2) Motor overcurrent
        3) Incoming power line over/under/unbalanced-voltage
        4) AFD over-temperature
        5) AFD over-voltage
        6) AFD control failure
7. Safety Features:
    a. The AFD shall include:
        1) Padlock main disconnect handle in the “Off” position.
        2) Mechanical interlock to prevent opening enclosure door with disconnect in the “On” position while the unit door is open.
        3) Auxiliary contact on main disconnect to isolate 120Vac control power when fed from external source.
        4) Barriers and warning signs on terminals that are energized with the power disconnect “OFF”.
        5) Separation and insulated barriers between the power and control and instrument products.
        6) External emergency stop input
8. Reverse Direction Protection:
    a. Provide protection from inadvertent operation in reverse where reverse rotation can damage the driven equipment.
9. Critical Speed Bypass:
    a. Provide capability to program speed bypass for minimum two critical speed points.
10. Transient Voltage Protection:
    a. Provide solid state transient voltage protection to meet or exceed ANSI C37.90.

2.04 CONTROL AND MONITORING DEVICES

A. Front door mounted on the AFD enclosure between 36 inches and 72 inches above the floor for each unit:
    1. Digital Operator keypad/display.
    2. Local-Off-Remote door mounted selector switch.
    3. Manual speed control: OIU function

4. Internal terminal strips for remote monitoring:
    a. Run status
    b. Trouble / Fail alarm
    c. Auto Mode status
    d. Additional devices as indicated on the drawings.

B. Operator Interface Unit:
1. Digital keypad/display for monitoring and controlling the drive and to input drive parameter settings with a backlit LCD or equally visible display with a minimum of 16 characters per line.
2. Digital keypad for numerical settings in English engineering units and a guide to parameter settings. Setup operations and adjustments stored in non-volatile EEPROM memory transferable to new and spare boards. Settings shall be protected from unauthorized tampering, revision, or adjustment by a personal lockout code.
3. The digital keypad to provide programming of the drive and include:
    a. Up and Down Arrow Keys:
        1) Increase or decrease output frequency or data values.
    b. Monitor Key:
        1) Selection of control mode.
    c. Run and Stop Keys:
        1) Starting and stopping in the manual mode.
    d. Fault Clear / Enter Keys:
        1) Reset fault conditions and enter change
    e. Program Key:
        1) Enter the program mode and adjust parameters.
    f. Remote / Local Location Keys:
        1) Operation location and local speed control.
    g. Auto / Manual Mode Keys:
        1) Program mode.
    h. Number Keys:
        1) 0 through 9 keys to access specific parameters.
    i. Keypad Digital Illustrations:
        1) English and display the last 5 faults.
    j. Frequency / Motor Speed Indication:
        1) Calibrated in Hertz and RPM.
    k. Run Status Indication.
    l. Ready Status Indication.
    m. Fault Alarm Indication.

C. Control and Monitoring Communication
1. None or:
    a. Additional analog I/O as required for the project
    b. Additional discrete I/O as required for the project

c. Thermistor inputs
d. EtherNet Communication Card]

2.05 KEYPAD FUNCTIONS AND OPERATION

A. Adjustment of the following parameters through the OIU digital keypad:
   1. Current limit and torque boost.
   2. Maximum voltage level.
   3. Minimum/Maximum speed, Volts/Hertz, Upper and Lower limit.
   4. Adjustable acceleration rate and deceleration rate.
   5. Electronic thermal overload setting.
   6. Coast, controlled ramp or DC injection selectable modes of stopping.
   7. PID setpoint and time-function selection.
   8. Critical frequency avoidance:
      a. Three set points selectable from 0 to maximum frequency with set points adjustable from 0-30 Hertz.

2.06 ARC FLASH MITIGATION METHODS

A. The following arc flash and mitigation method requirements shall apply. Refer to specification section 26 05 74, NFPA-70 (NEC) for arc mitigation requirements, and NFPA-70E (Standard for Electrical Safety in the Workplace) for equipment labeling requirements.

B. Equipment Labels:
   1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.

2.07 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of Section 26 05 00. Nameplates shall be provided for all drive enclosures. Provide equipment tag numbers and descriptions as shown on the drawings.

2.08 SPARE PARTS

A. The following spare parts shall be supplied with each type or frame size AFD:
   1. Three sets of all replaceable fuses.

2.09 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Operation and maintenance information as specified in Section 01 78 23, including:
      a. Final reviewed submittal.
      b. As-built drive configuration settings.
   2. Installation certification Section 43 05 11-Form A as specified in paragraph 3.01.
   3. Training certification Section 43 05 11-Form B as specified in paragraph 3.03.

PART 3 EXECUTION

3.01 FIELD INSTALLATION

A. Each adjustable speed controller shall be installed and tested by the Contractor with the assistance of factory-trained pump manufacturer engineer/technician and AFD engineer/technician in accordance with the manufacturer's specifications and Section 26 29 23, and witnessed by the Construction Manager.

B. Manufacturers' factory representatives shall provide field testing for devices including the setup of the Operator Interface Unit and the setup of the data communication devices, where used. Upon satisfactory completion of the testing, the Contractor shall submit two certified copies of the test report to the Construction Manager.

C. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.

D. The installation shall be certified on Form 43 05 11-A specified in Section 01 99 90.
   1. Adjust drive and perform "start-up" tests as recommended by manufacturer. Set parameters and carrier frequency for existing motors to avoid insulation damage.
   2. Establish proper direction of rotation for the motor controlled by the drive. Verify that the AFD is precluded from operating in a direction that can damage the driven equipment. Change motor or AFD power lead connection and not the AFD direction, where rotation is incorrect.
   3. Verify that the drive will operate properly both in the "manual speed control mode" and in the "remote or automatic mode" from a remote speed signal input.
   4. Set the maximum "locked rotor" current drawn during start-up recommended by the manufacturer and approved by the Construction Manager.
   5. Set the minimum and maximum speeds and the acceleration and deceleration "ramps" recommended by the Construction Manager.
   6. Verify the motor high temperature switch contacts are wired into the AFD 120 Vac control circuit and will trip on high winding temperature. Test or simulated the alarm and trip feature at the motor for high temperature and for high vibration, where used.
   7. Operate the drive at 100 percent speed for one hour and monitor output current. The output current shall remain below the full load current listed on the motor nameplate.
   8. Check for excessive heating of the drive and motor. Report any discrepancies to the Construction Manager.

3.02 HARMONIC TESTING

A. The Testing Firm specified in Section 26 08 00 shall perform a harmonics acceptant test with all AFD motor controllers operating to verify compliance with IEEE-519 of less than 5 percent voltage THD and 12 percent current THD at the defined point of common connection when running from Power Utility power source with a BMI-Dranetz or equal harmonic test set that provides a hard-copy record of the test results.

B. The test shall also be run with power sourced from the standby generator where such a power source is being used at the project site. THD shall be limited to a maximum level of 8 percent voltage THD on standby generator operation.

C. Submit the test performance to the Construction Manager per latest version NETA ATS Acceptance Testing Specifications. Refer to the electrical testing specification Section 26 08 00.

3.03 TRAINING

A. Two hours of onsite AFD operation and maintenance training shall be provided for the Owner's Operation and Maintenance Staff.

B. Manufacturers' factory representative shall conduct the training, upon acceptance of a resume submitted by the trainer.

C. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

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SECTION 26 32 13.13

DIESEL ENGINE DRIVEN GENERATOR SETS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This Section specifies the requirements for providing, factory testing, and on-site acceptance testing of complete and operable standby diesel engine driven generating system (GenSet). This section covers outdoor diesel engine generator sets with outdoor metal enclosures used only for providing power during a loss of utility power. Equipment provided under this section is not suitable for peak shaving, or any other unrestricted long-term operaton that would have to meet Tier 4 emission standards. This section also inlcudes [,belly tank fuel storage container,] and the devices and equipment required for the system operation. [A separate fuel storage container for the GenSet fuel supply is specified in Section [26 32 13.15].]
2. Refer to the Section 26 36 23 that specifies the Automatic Transfer Switches (ATS) supply, custom features, factory tests by the generator manufacturer and the GenSet supplier, and shipping the ATS to the project site for installation. The ATS will not be installed within the GenSet enclosure.

B. The generator shall have two main breakers with kirk-key interlock with connections for:

1. One set of standby feeders to the ATS.
2. One set of portable load bank lead connections.

C. The generation system shall include the following:

1. Digital control, monitoring, and display system
2. Cooling system
3. Belly tank
4. Exhaust silencer: Mounted inside the enclosure.
5. Noise dampening mounting system.
6. Sound attenuated outdoor enclosure accessories.
7. Accessories: Including batteries, battery charger, block heater with 120/240 Vac 100-ampere panel for lights, power outlets, battery charger, and block heater.
8. Control system testing
9. [Temporary Test Load Bank] [Permanently Installed Load Bank]
10. Testing with load bank

D. Operating Requirements:

1. The electric power generating system shall have ratings as indicated with 0.80 power factor, 480 volts, WYE connected generator, three-phase, three-wire, 60-Hertz, 1800 rpm and rated for Standby operation per NEC Article-700, Article -701 or Article-702.

E. Generator Set Schedule:

Tag No.	Description / Location	Enclosure	Rating
GEN-2500	Operations Building Diesel Fueled Generator	Indoor	1000-kW, 3-Phase, 3-Wire

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI C57.13	Requirements for Instrument Transformers
IEC 34-5	Rotating Electrical Machines - Part 5: Degrees of Protection by Enclosures for Rotating Machinery
IEC 60529	Degrees of protection provided by enclosures (IP Code)
ISO	International Organization for Standardization
NEMA MG1	Motors and Generators
NEMA MG2	Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators
NEMA SG31	Low Voltage Power Circuit Breakers
NEMA SG51	Power Switchgear Assemblies
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	National Electrical Code (NEC)
NFPA 110	Standard for Emergency and Standby Power Systems
OSHA	Occupational Safety and Health Act
SAE J 1349	Society of Automotive Engineers Engine Power Test Code
UL	Underwriters Laboratories Inc.

B. Unit Responsibility:
   1. The Contractor shall assign unit responsibility, as specified in Section 43 05 11, to the manufacturer of the GenSet provided under this section. This manufacturer is the unit responsibility manufacturer and has unit responsibility, as specified in Section 43 05 11, for both the GenSet equipment assembly specified in this section and for the automatic transfer switch specified in Section [26 36 23]. A completed, signed, and notarized Certificate of Unit Responsibility (Section 01 99 90-Form 43 05 11-C) shall be provided.

C. Design Requirements:
   1. Engine:
      a. Rating:
         1) Engine brake horsepower shall be sufficient to deliver full rated GenSet kW/kVA when operated at rated rpm and equipped with all engine-mounted parasitic and external loads such as radiator fans, fuel pumps, and cooling water pumps.
      b. Fuel:
         1) Diesel engines shall be able to deliver rated power when operating on ultra low-sulfur No. 2 diesel fuel.
      c. Fuel Consumption:
         1) Diesel fuel rates shall be based on fuel having a low heating value (LHV) of 42,780 kJ/kg (18,390 Btu/lb) when used at 29°C (85°F) and weighing 838.9 g/l (7.001 lb. / U.S. gal).
   2. Generator:
      a. Motor starting:
         1) Solid-state-starters, variable speed controllers, or auto-transformer reduced voltage starting with the typical RVAT start would be on the 65% tap, as indicated.
      b. Generator Performance:
         1) Voltage dip for motor starting shall not exceed 25% for any individual load step.
   3. GENSET Start time and load acceptance: Engines shall start, achieve rated voltage and frequency, and be capable of accepting load within 10 seconds.
   4. Outdoor Enclosure:
      a. GenSet enclosure shall be designed to resist the loads prescribed by the Governing Building Code including: Dead, Live, Wind, Seismic, Rain, Snow, and Ice.
      b. GenSet enclosure shall also be designed to support any superimposed loads imparted from system components mounted to it, including those identified in Section **Error! Reference source not found.**
      c. In no case shall the enclosure be designed to resist loads less than the minimum loading conditions listed below:
         1) Roof live load: 50 psf
         2) Floor live load (when equipped): 200 psf
         3) Wind Load design speed: 100 mph

D. Noise Requirements and Control:

Sound pressure level when operating fully loaded shall not be greater than [ ] dBA at the nearest fenceline.

E. Manufacturer's Qualifications and Warranty:

1. The complete power generation system shall be the product of one manufacturer who has been regularly engaged in the production of complete generating systems for at least twenty-five years.
2. The supplier shall be the engine-generating system manufacturer's authorized local representative that shall provide installation assistance, start-up services, and Owner's staff training. The supplier shall have 24-hour service availability with factory-trained technicians qualified to perform trouble-shooting, repairs on the system, and warranty and post warranty -compliance services.
3. Preventive maintenance to be performed by:The GenSet supplier shall provide the following warranty that includes battery warranty:
    a. Two year parts and labor with travel time included.

F. Manufacturer Factory Testing:

1. Functional Tests:
    a. Functional testing of the complete power generation system final assembly shall be performed at the GenSet manufacturer's factory to assure proper system operation.
2. GenSet shall be load tested after the assembly is installed into the enclosure and operate continuously without stoppage for a period of 8 hours.
3. GenSet shall operate for one hour at ½, ¾, and full load, at 0.8 power factor or greater. Restart the test, if stopped for any reason.
4. Prototype Test:
    a. The GenSet manufacturer shall certify that engine, generator, and controls have been tested as complete systems in accordance with NFPA 110 of representative engineering models (not on equipment sold).
5. Sound Test:
    a. Provide a GenSet factory test for sound pressure level measured in accordance with IEEE Standard 85, Test Procedure for Airborne Sound Measurement on rotating electrical machines or propose acceptable alternate to free field sound test. Refer to paragraph 1.02 for sound test criteria.

G. Shipment, Handling, and Storage:

1. The equipment shall be protected during shipment, handling, and storage per Section 01 66 00.

1.03 ENVIRONMENTAL CONDITIONS

A. General:

1. The GenSet manufacturer shall verify that the diesel engine is correctly sized and is capable of driving the generator with all accessories in place and operating, at the generator's kW rating after derating for the range of temperatures expected in service and the project site altitude, per NEMA MG1.

B. Seismic:
   1. Equipment and supports shall be braced per Section 01 73 23.

C. Site Conditions:
   1. The site conditions are:
      a. 40 degrees C maximum ambient
      b. 5335 feet altitude per Section 01 11 80

1.04 SUBMITTALS

A. The following submittals shall be provided in accordance with the requirements of Section 01 33 00.
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
      a. Section 26 36 23 Automatic Transfer Switches
   2. A check mark (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
   3. Completed Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   4. Manufacturer and manufacturer's type designation.
   5. Manufacturer's catalog and/or other data confirming conformance to specific design, material and equipment requirements including:
      a. Engine:
         1) Type, aspiration, compression ratio, and combustion cycle
         2) Bore, stroke, displacement, and number of cylinders
         3) Rotational speed, RPM
         4) Engine lubricating oil capacity
         5) Engine coolant capacity without radiator
         6) Engine coolant capacity with radiator
         7) Coolant pump external resistance (maximum)
         8) Coolant pump flow at maximum external resistance
         9) Exhaust back-pressure (maximum allowable pressure)

10) Combustion air inlet flow rate
11) Exhaust gas, flow rate, stack temperature
12) Exhaust system back pressure (maximum)
13) Heat rejection to:
    a) coolant
    b) aftercooler
    c) lube oil
    d) exhaust
    e) atmosphere
14) Fuel Consumption:
    a) 50% load
    b) 75% load
    c) 100% load
15) Fuel supply system shall be external outdoor tank.

b. Generator:
    1) Model
    2) Frame
    3) Voltage
    4) kW
    5) Power Factor
    6) Frequency
    7) Insulation class
    8) Number of leads
    9) Weight, total
    10) Weight, rotor
c. Efficiency At rated voltage:
    1) Efficiency at 0.8 power factor for 50% load.
    2) Efficiency at 0.8 power factor for 75% load.
    3) Efficiency at 0.8 power factor for 100% load.
d. Radiator:
    1) Model
    2) Type
    3) Heat Rejection:
    4) BTU/Hour
    5) Fan drive ratio
    6) Coolant capacity, radiator
    7) Coolant capacity, radiator and engine
e. GenSet with enclosure Dimensions:
    1) Dimensions:
    2) Length, width, height
    3) Weight:
    4) Dry and wet

5) Vibration isolators

f. Power Rating:

g. Nominal full capacity standby kW at 0.8 power factor and corresponding kVA rating

6. Exterior paint color chip for enclosure per paragraph 2.07 Interior Lighting and Outlets.
7. Structural design calculations for the Structural Steel Frame supporting the generator, radiator and engine, stamped and signed by a Prefessional Engineer licensed and registered to practice in UT.
8. Drawings:
   a. General dimensions drawings showing overall GenSet measurements, mounting location, and interconnection points for load leads, fuel, exhaust, cooling and drain lines.
   b. General dimension drawings for fuel supply and storage system including interconnection points, fuel and drain lines, and level and leak detection equipment, terminal-boxes and panels.
9. Wiring diagrams, schematics and control panel outline drawings published by the manufacturer in Joint Industrial Council (JIC) format for controls and switchgear showing interconnected points and logic diagrams for use by contractor and owner.
10. Product Data
    a. Certified factory test results.
    b. Operation and maintenance information as specified in Section 40 61 21. In addition the following:
       1) Operating instructions with description and illustration of engine and generator controls and monitors.
       2) Manuals that illustrate and list assemblies, subassemblies and components, except the standard fastening hardware.
       3) Preventative maintenance instructions for daily, weekly, monthly, biannual, and annual maintenance requirements. Include a lubrication chart for all components.
       4) Routine test procedures for electronic and electrical circuits including the generator.
       5) Troubleshooting chart covering the complete GenSet with a description of trouble, probable cause, and suggested remedy.
       6) Recommended spare parts list showing consumables anticipated during routine maintenance and test.
       7) Wiring diagrams and schematics showing function of electrical components.
       8) Complete final submittals including Record As-Built drawings.
       9) Manuals and books described above shall be contained in rigid plastic pouches.
       10) Training certification Section 43 05 11-Form B specified in paragraph 3.03.
       11) Field test reports as specified.
       12) Warranty verification statements published by manufacturer.
       13) Location and description of supplier's parts and service facility including parts inventory and number of qualified GenSet service personnel.

c. Installation requirements showing clearances required for maintenance purposes: Access to main breaker, oil fill line, fuel fill line, etc.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

The candidate manufacturers include the following:

Equipment / Manufacturer / Supplier	Engine-Generator	Control Panel
[Manufacturer / Supplier 1	Caterpillar / Caterpillar	CAT EMCPIT]
[Manufacturer / Supplier 2	Cummins / Onan	Onan Power Command Amp Sentry Protection]

2.02 ENGINE EQUIPMENT

A. General:
1. The engine shall be a single stationary, liquid cooled, 1800 rpm, four-cycle design, direct injection engine with forged steel crankshaft and connecting rods. Systems with dual engine-generators will not be permitted.
2. The engine cylinder block shall be cast iron with replaceable wet liners with four valves per cylinder. Provide 6, 12, or 16 cylinders engine with turbocharger and after-cool, as required by the GenSet manufacturer.
3. The GenSet engine shall not be manufactured with any Class I ozone depleting substances (ODS) as defined by Federal Register Vol. 57 No. 86.
4. The GenSet shall be pre-certified EPA Tier-2 emission requirements and in comppliance with the local Air Pollution Control District (APCD) regulations, whichever is the more stringent. Certified test reports shall be furnished for APCD acceptance.

B. Structural Steel Frame:
1. The generator, radiator, and engine shall be securely mounted on a heavy welded steel frame structure frame that is stiffened and cross-braced to provide a rigid mounting base.

C. Engine Equipment:
1. The engine shall be equipped with manufacturers standard air filters, pressure gauges, lubricating oil cooler, filters, and pressure gauge, water pump and temperature gauge, service hour meter, flywheel, and flywheel housing when applicable.
2. Lube Oil Filter: Provide a lube oil filter, equipped with a spring-loaded bypass valve to ensure oil circulation if filters are clogged. Provide an oil drip pan for mounting underneath the engine. Provide an oil drain extension.

D. Engine Fuel System:
   1. Fuel Strainer and Filter:
      a. Provide fuel strainer and filter between engine fuel pump and engine. Provide indicating pressure gauges on both upstream and downstream side of strainer and filter.
   2. Fuel Lines:
      a. Flexible braided stainless steel fuel lines between engine and fuel supply shall be provided to isolate vibration.
   3. Fuel System Maintenance:
      a. The fuel transfer pump, injection pumps, rack and pinion assembly, and timing mechanism shall be maintenance and adjustment free for the life of the equipment. The fuel filter shall not require changing more frequently than once per year or every 250 hours. Provide a fuel filter with spill containment and catch pan for about three gallons of fuel.

E. Governor:
   1. General:
      a. The engine governor shall control engine speed and transient load response. The governor shall be selected, installed, and tested by the GenSet manufacturer.
   2. Speed Control:
      a. The engine governor shall be an electronic speed-control actuator. Speed droop shall be 0 (isochronous) from no load to full rated load.
   3. Frequency Regulation:
      a. The steady state frequency regulation shall be within 0.25%. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear.
   4. Remote Speed Control:
      a. A provision for remote speed adjustment shall be provided.
   5. Actuator:
      a. The forward acting actuator shall move to the minimum fuel position in the event of a DC power loss.

F. Cooling System:
   1. General:
      a. The engine jacket water cooling system shall be a closed circuit design with provision for filling, expansion, and de-aeration.
         1) The cooling pump shall be driven by the engine. Auxiliary coolant pumps required for heat exchangers or separate circuit after-cooling shall be engine driven.
         2) The cooling system shall tolerate at least 172 kPa (25 psi) static head. Coolant temperature shall be internally regulated to disconnect external cooling systems until operating temperature is achieved.
   2. Engine Mounted Radiator:
      a. Heat rejected to the engine jacket water shall be discharged to the atmosphere through a close-coupled radiator.

3. Coolant:
    a. The unit shall have an antifreeze / coolant mixture. The radiator shall cool the jacket water while the engine is operating at full site capability and 0.123 kPa (0.50 inch water column) external air restrictions.
        1) Additional restriction affecting airflow shall not limit the radiator's capability to adequately cool at maximum site temperature. Provide air flow to meet ambient conditions at specified ratings at 100% rated connected load.
4. Fan and Belt Guarding:
    a. The fan, fan drive, and fan belts shall be covered with 14 gauge punched steel mesh guarding for personnel protection. The guarding shall conform to IEC 34-5, ISO and OSHA standards.
5. Radiator Fan:
    a. The radiator-cooling fan shall be a propeller type driven from the engine with the air drawn from the engine side and exhausted through the radiator core.
6. Inlet Air System:
    a. The engine air cleaner shall be engine mounted with maintenance access. The maximum restriction to the combustion air inlet shall not exceed engine manufacturer requirements where external ducting provided.

G. Exhaust System:
1. General:
    a. The engine exhaust system shall discharge combustion gases safely and without leakage with minimum restriction. The critical sound silencer shall be designed for minimum restriction without excessive back-pressure.
        1) Engine exhaust piping shall be Schedule 40 carbon steel with long radius 90 degree bends. Piping shall be installed with 9 inch minimum clearance from combustible material or incorporate appropriate insulation and shielding, as appropriate for personnel safety. Provide a stainless steel flexible connection between the engine and exhaust piping.
        2) Exhaust piping shall be supported and anchored to prevent weight or thermal growth being transferred to the engine. Flexible expansion fittings provided to accommodate thermal growth. Support dampers and spring isolators provided to isolate vibration.
        3) Long runs of exhaust piping shall be pitched away from the engine and water traps installed at the lowest point. Provide a 1-inch diameter capped sample port for emissions testing. Provide ports 90-degrees apart on a straight section of exhaust piping.
        4) Exhaust stacks shall be extended to avoid fumes and odors inside enclosure and installed to minimize noise.

2. Silencer-Critical:
    a. Exhaust Silencer: The exhaust silencer shall be a critical-grade type exhaust silencer. Exhaust noise shall be limited to 75 dBA as measured at 10 feet in a free field environment. Silencer shall be Maxim, Nelson, or equal. Silencer shall have mounting/seismic restraint lugs, and shall have a one-inch condensate drain connection. A 2-1/2-quart, low pressure, manual drip trap (Varec Figure No. 246, Groth Model 8460, or equal) shall be provided loose for installation by the Contractor. The silencer shall be fabricated of heavy-gauge steel in all-welded construction with inspection ports and drain fittings in each chamber. Exhaust system (pipe, fittings, and silencer) shall be coated in accordance with Coating System H-1 (Section 09900). Once painted, exhaust system shall be insulated in accordance with Section 15250.

H. Flexible couplings for jacket water, lube oil, fuel and exhaust piping shall be provided. Water, oil and fuel connectors shall be single braided, stainless steel, 150 psig working pressure. Fuel connectors shall bear the Underwriters Laboratories label. The exhaust connector shall be unbraided, stainless steel, suitable for temperatures up to 1300 degrees F. All connectors shall be selected for a design of not less than 10,000,000 full displacement cycles. Flexible metal hose shall be by Flexonics, Hyspan, or equal

2.03 GENERATOR SYSTEM

A. Generator:
1. The generator shall be synchronous, four pole, revolving field, pre-lubricated bearing, air cooled by a direct drive centrifugal blower fan, and directly coupled to the engine with flexible drive discs.
2. The armature shall have skewed laminations of insulated electrical grade steel, two-thirds pitch windings. The rotor shall have amortissuer damper windings of layer-wound, mechanically-wedged winding construction. The rotor shall be dynamically balanced.
3. Insulation system components shall meet NEMA MG1 temperature limits for a Class H insulation system. Actual temperature rise measured by resistance method shall not exceed 125 degrees Celsius to provide additional allowance for internal hot spots.
4. The generator insulation systems shall be suitably impregnated for operation in severe environments for resistance to sand and other air-born contaminants.

B. Exciter:
1. A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator for immunity from voltage distortion caused by non-linear loads on the generator.
2. The PMG shall sustain field excitation power for optimum motor starting and shall sustain short circuit current for selective operation and coordination of system overcurrent devices.
3. The PMG exciter insulation systems shall be suitably impregnated for operation in severe environments for resistance to sand and other air-born contaminants.

C. Voltage regulator:
   1. The automatic voltage regulator shall be temperature compensated, digitally controlled pulse width modulated solid-state design, and include over-voltage and over-current protection functions.
   2. Over-voltage protection shall sense generator output voltage, In the event of regulator failure or loss of reference, the regulator shall shut down its output on a sustained over-voltage of one-second duration.
   3. Over-excitation protection shall sense regulator output and shut down its output if overload exceeds ten seconds duration. Both over-voltage and over-excitation protection shall be latched, requiring the generator to be stopped for reset.
   4. Generator output voltage shall be maintained within 1% of rated value for any load variation between no load and full load and drift no more than within 0.5% of rated value at constant temperature.

D. Circuit Breaker:
   1. The generator mounted circuit breaker shall be mounted and connected in a guarded drip proof freestanding enclosure meeting, NEMA 3R requirements and provided with adequate space for customer power cable lug connections. Cable lugs by supplier, refer to the electrical drawings for circuit conductor sizes and numbers.
   2. Provide the following:
      a. Molded case circuit breaker rated for 100% current, 3-pole, single-throw, stationary-mounted with manual operating handle, overload and short circuit trips, complete with cable lugs.
      b. Circuit breaker shall be UL labeled and rated for 600-volt circuits and provided with a solid state over-current trip device.
      c. Circuit breakers rated shall have ground-fault protection and ground-fault indication.
      d. A circuit breaker with a 24 Vdc shunt-trip unit wired to terminal board.
      e. Three current transformers with 5-ampere secondary windings for the ammeter display, as needed.
      f. National Electrical Code required working access space around the Circuit Breaker enclosure.

2.04 ENGINE-GENERATOR SYSTEMS

A. Engine Starting System:
   1. The engine starting system shall include 24 Vdc starting motor(s), starter relay, and automatic reset circuit breaker to protect against butt engagement.
   2. Required cables furnished and sized for power feeder circuit requirements and capable of starting the specified engine within 10 seconds at the elevation and ambient environmental conditions specified herein.

B. Water Jacket Heater:
   1. Jacket water heater(s) shall be provided to maintain coolant temperature of 32°C (90°F) while the engine not running. Heaters shall accept 208 Vac single phase power and include thermostatic controls.

C. Batteries:
   1. Batteries for GenSet starting and control shall be selected and supplied by the GenSet manufacturer. Battery warranty shall be the responsibility of the GenSet manufacturer. Batteries shall be protected from engine fuel leaks.
   2. Batteries shall be maintenance free SLI lead acid type with through-partition connectors and mounted near the starting motor. Batteries shall be mounted on a corrosion resistant or coated steel battery rack close to the starting motor as practical and allow personnel access for inspection and maintenance.
   3. Starting batteries shall be rated 24 Vdc with ampere-hour and ampacity sizing to provide a minimum of 210-ampere-hour 1,250 cranking amperes that includes the sizing requirements to allow for engine oil viscosity, ambient starting temperature, project elevation, and accessories.

D. Alternator:
   1. An engine-mounted belt-driven battery charging alternator shall be installed with an automatic voltage regulator. Alternator and regulator suitable for the application with a rating of 24 Vdc output with 45-amperes minimum.

E. Battery Charger:
   1. A dual rate 10-ampere battery charger shall be provided that shall accept 120 Vac single phase input to provide 24 Vdc output.
   2. The battery charger shall be fused on the AC input and DC output, and incorporate current limiting circuitry to avoid the need for a crank disconnect relay. The charger shall be rated for operation at plus 50°C ambient. Charger voltage regulator shall be temperature compensated.
   3. The battery charger shall be provided with the following: corrosion resistant enclosure, on/off switch, dc ammeter, dc voltmeter, ac input and dc output circuit breakers or fuses, floating voltage equalization, equalizing timer, and relays with form c contacts for remote annunciation of loss of AC power, low battery voltage, and high battery voltage.
   4. A voltage power switch shall be mounted on the face of the charger and shielded from accidental switching. The charger shall include an AC ammeter and voltmeter, a failure malfunction alarm switch, and be housed in an enclosure suitable for mounting inside the outdoor enclosure.
   5. The batteries, battery rack, and battery charger shall be located inside a separate vented enclosure inside the engine-generator enclosure. The battery rack frame shall be constructed of corrosion resistant material.

2.05 CONTROLS

A. Engine-Generator Control Panel:
   1. The control panel shall be designed and built by the engine-generator manufacturer and mounted near the generator with vibration dampening mounting devices.
   2. Provide a 100 percent solid state microprocessor based control circuitry, sealed dust tight, watertight modular components, and digital instrumentation. Provide NEMA 12 enclosure ratings. Comply with NEMA 250 standards for enclosure protection. Label the control panel with ISO symbols.

3. Display critical parameters such as operating hours, engine RPM, battery DC volts, oil pressure, jacket water temperature, including the specified engine and electrical parameters.

B. Engine monitoring Devices:
   1. Engine monitoring signals provided by engine mounted lubricating oil pressure and coolant temperature transducers shall communicated over a serial data link through a Data Sending Unit (DSU) to the control panel receiving module. The safety logic shall shut the engine down if the serial data link is lost.

C. Control Functions:
   1. Provide control panel front mounted devices such as generator voltage control device, ammeter/voltmeter phase selector switch, control selector switches, and pushbuttons. Provide control and monitor devices identified and labeled with ISO symbols.
   2. Provide start-stop logic for cycle cranking and cool down operation and red-mushroom head emergency-stop maintained pushbutton.

D. Control Wiring:
   1. GenSet control wiring:
      a. Number 16 AWG stranded wire and control panel ground wire
      b. Number 12 AWG with green and yellow striped insulation rated. Conductors shall be rated 90°C 600 Vac insulation with UL or CSA listing.
      c. Provide wire identification on the conductor 6-inches from the terminal and protect wire from sharp bends and metal edges.
      d. Provide four sets of Form C dry contacts rated at 2 amps for remote customer alarming.

E. Alarm and Shutdown Conditions:
   1. Indicate the following alarm and shutdown conditions and provide a RESET device to clear fault:
      a. Low oil pressure: pre-alarm
      b. High engine temperature: pre-alarm
      c. Low engine temperature: pre-alarm
      d. Low fuel: pre-alarm
      e. Low battery DC voltage: pre-alarm
      f. Generator output circuit breaker (trip or off): alarm
      g. Generator overload: alarm
      h. Low oil pressure: shutdown
      i. High engine temperature: shutdown
      j. Low coolant level: shutdown
      k. Over-crank: shutdown
      l. Over-speed: shutdown
      m. Over-voltage: shutdown
      n. Under-voltage: shutdown
      o. Under-frequency: shutdown

p. High battery voltage alarm
q. Low battery voltage alarm
r. Normal battery voltage indication
s. Battery charger malfunction alarm
t. Spare (2): alarm and shutdown

F. Metering:
1. Provide digital metering with 0.5% accuracy. Provide true RMS indication that includes the total harmonic voltage and current content:
a. Voltmeter
b. Ammeter
c. Frequency meter
d. Phase select switch
e. Non-resettable running time

G. Alarm Module:
1. Provide integral digital alarm annunciator for indication and audible alarm per NFPA Standard 110 on the engine-generator control panel. Provide lamp test switches, alarm horn silence-button, and first-out alarm detection.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. The GenSet shall be installed and connected in accordance with manufacturer's recommendations and the installation shall be certified on Form 43 05 11-A as specified in Section 01 99 90.
2. Verify the equipment pad is sized for the GenSet size per submittal information, level, with ground pad installed.

B. Signs:
1. Provide NEMA MG1-22.61 GenSet nameplate. Provide laminated equipment, device, and panel nameplates per specification Section 26 05 00.
2. Provide one sign in accordance with NEC [700.7] [701.7] [702.7] for Contractor installation on the Service Entrance Equipment. Sign shall conform to NEC 110.21(B), and shall describe the type and location of the generator.

C. Conduit Transitions at Slab:
1. Connection from underground conduits to GenSet equipment shall transition via PVC coated flexible steel conduits. Loose or open cabling will not be permitted.

D. Protection Post Barriers:
1. Provide a minimum 4-inch diameter concrete filled 36-inch high posts around the GenSet. Post shall be removable with locking pin device to keep in place. Provide post at each corner within 3-feet from the enclosure and with 3-feet between posts.

3.02 FIELD INSPECTION AND TESTING

A. Pre-Delivery Inspection:
   1. Provide a pre-delivery inspection performed by the system manufacturers' local dealer at the dealer's facility to insure no damage occurred in transit. Verify GenSet components, controls, and electrical equipment is included as specified herein. Verify the NEC work access to electrical power equipment and control equipment is provided as specified.

B. Pre-Delivery Supplier Facility Testing:
   1. Prior to delivery of the GenSet to the project site, test the GenSet to verify it is free of defects, starts automatically, and carry full load. Test shall be performed at the facility of the system manufacturer's authorized supplier.
   2. The testing shall be done on dry type, resistive load banks capable of precise incremental loading. Salt water brine tanks or load banks requiring water as a source of cooling will not be allowed.
   3. Provide separate test grade instrumentation to monitor the GenSet using the load bank. The GenSet monitoring instruments shall be read and compared to the amperage and voltage on each phase. Both readings shall be recorded and compared in the test report.

C. Pre-Delivery Testing Procedure:
   1. Provide a pre-delivery test and operation that includes the ATS setup, test, and operation performed by factory trained technicians with test equipment, facilities, and consumables provided by the supplier.
   2. [Owner Representative] [Construction Manager] shall be scheduled to witness all tests. The test shall be performed on the complete fabricated GenSet within sound attenuated enclosure.
      a. Check electrical, exhaust, fuel and water connections for proper size, continuity and tightness of fittings.
      b. Check fluids for appropriate levels and jacket water heater operation.
      c. Correct defects during the test at no additional cost to the Owner prior to shipment to the job site.
      d. Connect a 100 percent rated resistance load bank equivalent to the nameplate rating at unity power factor.
      e. The GenSet shall be run for 1.5 hours during first initial run for proper engine break-in, (0.5-hour no-load, 0.5-hour at 50 percent rated load, 0.5-hour at 75 percent load) then 100 percent for 2 hours, or similar manufacturer recommended test operation sequence.
      f. The test period shall extend until oil and water temperatures have stabilized for a period not less than 30 minutes.
      g. Maintain test records at fifteen minute intervals to record water temperature, fuel pressure, oil pressure, ambient air temperature, voltage, amperage, frequency, kilowatts and power factor.
      h. Test safety devices using methods recommended by the manufacturer.
      i. Test results shall be documented and submitted for approval.
      j. Setup the control system to allow engine to cool before shutdown.

D. On Site Post-Installation Testing:
   1. Following installation, the following tests shall be performed by the system manufacturer's qualified representative in the presence of the Owner's representative.
   2. Pre-start Checks:
      a. oil level
      b. water level
      c. day tank fuel level
      d. battery connection and charge condition
      e. engine to control interconnects
      f. GenSet intake/exhaust obstructions
      g. engine room ventilation obstructions
      h. removal of all packing materials

E. Field Tests:
   1. The GenSet field test shall be performed by factory trained technicians at the project site with test equipment, facilities, and consumables including fuel and lubricants provided by the supplier. Provide a full tank of diesel fuel when the testing is completed and the GenSet is available for operation.
   2. Owner’s representatives shall witness the field tests. Contractor shall provide to the Construction Manager written notice of the date field testing will commence a minimum of two weeks prior to that date.
   3. The following field tests shall be conducted:
      a. Check electrical exhaust, fuel and water connections for proper size, continuity and tightness of fittings.
      b. Check fluids for appropriate levels and jacket water heater operation.
      c. Start-up engine and make initial start-up check of operational equipment.
      d. Upon completion of initial start-up and system checkout, schedule the witnessed field test to demonstrate load carrying capability, stability, voltage and frequency.
      e. Operate the GenSet for l-hour for proper engine break-in and record water temperature, fuel pressure, oil pressure, ambient air temperature, voltage, amperage, frequency, kilowatts, and power factor.
      f. Operate a minimum of 4-hours under full load with consumables necessary for testing furnished by the bidder.
      g. Return to normal power source and test the ATS transfer from normal power to standby power and the ATS monitoring functions by simulating the loss of normal power source.
      h. Test the ATS initiated "GenSet Start" condition with the load bank.
      i. Run the generator for test duration; monitor the oil and water temperatures and record readings every fifteen minutes.
      j. Test the GenSet safety devices using methods recommended by the manufacturer.
      k. Setup the unloaded run at the conclusion of the test and the retransfer to normal power to allow engine to cool before engine shutdown.
      l. Notify the Owner’s representative of problems and the mitigation plan.

m. Submit the formal Test Results Report for approval.

3.03 TRAINING

A. The Contractor shall contract with the GenSet manufacturer to provide 8-hours of training for each of the subjects below. Arrange and schedule the training with the Owner.

B. Training shall include the requirements of Section 01 79 00 and the following:
   1. Operations and Maintenance for the Diesel Engine and Fuel System.
   2. Operations and Maintenance for the AC Generator.
   3. Operations and Maintenance for the Control Panels, Battery System, and Enclosure Systems
   4. Operational information for the specific equipment provided.
      a. Operation of the equipment in automatic and manual modes.
   5. Troubleshooting.
   6. Routine maintenance.

C. Training shall be certified on Form 43 05 11-B as specified in Section 01 99 90.

END OF SECTION

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. Contractor shall provide the lightning protection system design by a qualified Lightning Protection System (LPS) firm registered to design lightning protection systems.
   2. Contractor shall furnish and install a complete lightning protection system for the following facilities and structures:
      a. Treatment Building
   3. Contractor shall test and certify that the lightning protection system design, installation, and testing comply with the lightning protection industry standards as applied to the project facilities and structures.
   4. Contractor shall provide the LPS firm with the plant or facilities drawings that indicate the equipment, buildings, structures, and HVAC equipment as the basis for their design work.
   5. Contractor shall submit the design drawing to the Design Review Agency for approval and to the Engineer for reference.

B. Coordination:
   1. Lightning Protection Systems design shall be arranged in accordance with the class of structure to be protected.
   2. Coordinate arrangement and connections with roof system proposed for use and roof mounted equipment. Refer to the structural and architectural drawings provided by the Contractor.

C. Related Sections:
   1. Contractor shall coordinate the requirements of the Work in this Section along with the requirements of the sections listed:
      a. Section 26 05 00 – Common Work Results for Electrical
      b. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

1.02 QUALITY ASSURANCE

A. Quality Control:
   1. Lightning protection system materials shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems.
   2. Materials shall comply in weight, size, and composition for the class of structure to be protected.
   3. Lightning protection systems shall be installed under the direct supervision of a Lighting Protection System Certified Master Installer.

B. Certification Requirements:
   1. Provide and submit Master Installer Certified forms for the following:
      a. Form LP1-175A - Jobsite Witness of Grounding Connections.
      b. Form LP1-175B - Post-Installation Inspection.
      c. UL Master Label C.

C. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/IEEE C62.1	Surge Arresters for AC Power Circuits
ANSI/IEEE C62.11	Metal-Oxide Surge Arresters for Alternating Current Power Circuits
LP1-174	Lightning Protection Institute Installation Code
LP1-175	Lightning Protection Institute Standard of Practice
NEC	National Electric Code (NEC): Article 230 – Services Article 250 – Grounding Article 280 – Surge Arrestors Article 501 – Class I Locations Article 502 – Class II Locations Article 800 – Communications Circuits
NFPA-780	Lightning Protection Code
UL Standard No. 96	Lightning Protection Components
UL Standard No. 96A	Master Label Provisions

1.03 SUBMITTALS

A. Shop Drawings:
   1. The following submittals shall be provided in accordance with Section 01 33 00
      a. Manufacturers technical information for materials proposed for use.
      b. Complete scaled drawings identifying the system arrangement and equipment connections for each building.

c. Drawings shall include equipment connection details, down-lead details, routing of system conductors, and locations of air terminals.

B. Master Label Certificates:
   1. Submit certificates for LP1 Code Compliance together with UL Master Label C certificates.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials:
   1. General:
      a. System materials shall be copper and high copper-content bronze castings.
         1) Fittings, except cable holders, shall be heavy-duty type made from bronze castings.
         2) Terminal rods, bolts, screws, and related type hardware shall be copper clad steel or brass to prevent galvanic corrosion.
   2. Components:
      a. The system shall consist of the necessary equipment as required to provide a complete and coordinated system. Cable and air terminals used shall bear the UL Label. The components shall consist of, but not limited to, the following:
         1) Cables.
         2) Air terminals.
         3) Mounting bases.
         4) Fittings.
         5) Couplings.
         6) Connectors.
         7) Fasteners.
         8) Conduit.
         9) Pitch pads and weatherproof seals.

2.02 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate firms are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

B. The candidate detailed design, product manufacturer, and installation firm shall be one of the following or accepted equal:
   1. Thompson Lightning Protection Inc.
   2. AC Lightning Security.

C. Early Streamer Emission (ESE) is prohibited product system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Verify field measurements as indicated on the drawings and as specified elsewhere herein.

B. Conceal system conductors where practical and main down-leads and roof risers shall be concealed within the building walls or columns.

C. Allow six foot minimum clearances as required by the NEC from:
   1. Lightning rod conductors to non-current-carrying metal parts of electrical equipment unless they are bonded to the rods;
   2. Lightning conductors to open conductors of communications systems;
   3. Lightning protection grounding electrodes to electrodes of other grounding systems.

D. Do not use lightning protection rods and electrodes in place of the grounding electrodes for electrical equipment.

E. Run leads in 1-inch Schedule-80 PVC plastic conduit.

F. Terminate upper end above floor ceiling, utilize through-roof connectors for cable roof penetrations. Conduit terminations at lower end to be 6-inch above finished ground level, to pinpoint locations during future inspections.

G. Bond metallic objects and systems at roof level.

H. Primary bonds using appropriate fittings and full-size conductor:
   1. Roof intake and exhaust fans, HVAC units, ductwork, piping, ladders, skylights, stacks, vents, etc.
   2. Down-leads to steel column or major framing member at every down-lead position.

I. Secondary bond using secondary cable and fittings:
   1. Metal bodies of inductance located within six feet of a conductor
   2. Equipment with primary bond.

J. Connect to structure ground grid system using exothermic welds.

K. Insure installation of air terminals to withstand wind force equivalent to 100 miles per hour with a gust factor of 1.3 without structural damage and without damage to the integrity of the lightning protection system.

L. Interconnect the Lightning Protection System to the building grounding grid at one location. Suggest the design indicate the interconnection be on opposite side of the building's service entrance location.

END OF SECTION

SECTION 26 41 23

LIGHTNING PROTECTION SURGE ARRESTERS AND SUPPRESSORS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies surge arresters used for the protection of electrical power equipment against surges caused by lightning or switching.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI C62.1	Surge Arresters for AC Power Circuits
NEMA LA 1	Surge Arresters

B. Design Test Data and Factory Tests:
   1. The manufacturer shall provide copies of design test data on the arresters provided showing that the arresters are in compliance with ANSI C62.1

C. The following tests shall be made on each arrester in conformance with ANSI C62.1:
   1. Power-frequency spark-over
   2. Radio influence voltage
   3. Sealing

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The surge arresters shall be valve-type designed to protect electrical power distribution equipment against overvoltages due to surges from lightning or switching. The arresters shall comply with ANSI C62.1 and NEMA LA 1.

B. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers for surge arresters suppliers include ABB, Eaton/Cutler Hammer, General Electric, Siemens, Square D, or equal.

2.02 CLASSIFICATION OF ARRESTERS

A. General:
   1. Surge arresters are classified according to prescribed ANSI test requirements.

B. Station Class:
   1. Where specified, station class arresters shall be provided on electrical distribution power equipment rated above 10,000 KVA unless otherwise specified.

C. Intermediate Class:
   1. Where specified, intermediate class arresters shall be provided on electrical power distribution equipment rated 10,000 KVA and below unless otherwise specified.

D. Distribution Class:
   1. Where specified, distribution class arresters shall be provided on electrical power distribution equipment.

2.03 RATING

A. The surge arresters shall be rated for the voltage class specified.

2.04 MOUNTING

A. The manufacturer shall provide the necessary mounting hardware.

2.05 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of Section 26 05 00.

2.06 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Certified design test data and individual test data for arresters as specified in paragraph 1.02 Design Test Data and Factory Tests.
   2. Operation and maintenance information items as specified in Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Unless otherwise specified, the surge arresters shall be mounted next to the equipment terminals. The terminations shall be torqued as recommended by the manufacturer.

END OF SECTION

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SECTION 26 42 00

CATHODIC PROTECTION

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. The CONTRACTOR shall install a cathodic protection system for the City Creek WTP yard piping, 24-inch and 36-inch welded steel pipe (WSP) with a dielectric polyethylene tape system. The cathodic protection system shall protect all associated pipes, joints, valves, fittings, etc., and includes electrical continuity (joint bonding), electrical isolation (insulating flanges), sacrificial (magnesium) prepackaged anodes, and cathodic protection testing facilities, in accordance with the Contract Documents.

B. The CONTRACTOR shall be responsible for review of the installation procedures under this and other Sections and for coordinating the installation of the corrosion control system, as required by the Contract Documents, and this specification.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. The publications listed below form a part of this specification to the extent referenced and are referred to within the text by the basic designation only.

B. Commercial Standards

1. American Society for Testing and Materials (ASTM)
    a. ASTM B3: Specification for Soft or Annealed Copper Wire
    b. ASTM B80: Specification for Magnesium-Alloy Sand Castings
    c. ASTM B843: Specification for Magnesium Alloy Anodes for Cathodic Protection
    d. ASTM D149: Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
    e. ASTM D257: Test Methods for DC Resistance or Conductance of Insulating Materials
    f. ASTM F436: Standard Specification for Hardened Steel Washers
    g. ASTM G97: Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications
2. American Water Works Association (AWWA)
    a. AWWA C217 Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipeline.
3. NACE International (NACE)
    a. SP0169: Control of External Corrosion on Underground or Submerged Metallic Piping Systems
    b. SP0286: Electrical Isolation of Cathodically Protected Pipelines
    c. TM0497: Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
4. National Fire Protection Association (NFPA)
    a. NFPA 70: National Electrical Code

5. NSF International (NSF)
    a. NSF 61: Drinking Water System Components – Health Effects

1.03 SUBMITTALS

A. Catalog cuts of all materials to be installed shall be submitted for approval.

B. Qualifications of the CONTRACTOR's Corrosion Engineer and Corrosion Technician, as outlined in the Quality Assurance Section 1.04, shall be submitted for approval.

C. Manufacturer's information for each item listed below shall be submitted for approval. (Include sufficient information to show that the materials meet the requirements provided herein, including references to specific sections and details shown on the Drawings.)
    1. Prepackaged Magnesium Anodes
    2. Flush-Mounted Cathodic Protection Test Stations
    3. Reference Electrodes
    4. Pipe Lead and Joint Bond Wire
    5. Thermite Weld Equipment and Materials
    6. Thermite Weld Coating
    7. Insulating Flange Components
    8. Coating for Buried Insulating Pipe Flanges
    9. Insulating Blankets
    10. Electrical Tape
    11. Cable Warning Tape

D. The following reports shall be submitted for approval:
    1. ASTM G97 current capacity test results.
    2. Insulating Flange/Joint Inspection Report.
    3. Electrical Isolation Testing Between Pipe and Steel Reinforcement Report.
    4. Baseline (Native) Potential Survey Report.
    5. A letter report documenting all testing performed during system installation and activation. The letter report shall include a description of the test methods, all data, analysis of the data, and conclusions about the cathodic protection system's effectiveness.

1.04 QUALITY ASSURANCE

A. The criteria used to indicate adequate corrosion protection of the metallic water pipeline shall be as listed in NACE Standard SP0169.

B. The installation of the cathodic protection system's electrical components shall conform to the National Electrical Code NFPA 70, applicable federal, state, and local codes, and the recommendations of NACE Standard SP0169.

C. The criteria used to indicate adequate electrical isolation of the metallic water pipeline from structures not intended to be cathodically protected shall in accordance with NACE Standard SP0286.

D. Provide all materials, equipment, labor, and supervision necessary for the completion of all installations and testing.

E. Services of Corrosion Engineer: The Owner will obtain the services of a Corrosion Engineer to inspect, activate, adjust, and evaluate the effectiveness of the cathodic protection system. The Corrosion Engineer is herein defined as a registered Professional Engineer with certification or licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person accredited or certified by NACE at the level of Corrosion Specialist or Cathodic Protection Specialist (i.e., NACE CP Level 4). Such a person shall have not less than five years' experience inspecting pipeline cathodic protection systems.

F. Services of Cathodic Protection Technician: The Owner will obtain the services of a Cathodic Protection Technician to inspect, activate, adjust, and evaluate the effectiveness of the cathodic protection system. The Cathodic Protection Technician is herein defined as a person accredited or certified by NACE as a Cathodic Protection Technician (NACE CP Level 2). Such a person shall have not less than five years' experience inspecting pipeline cathodic protection systems.

G. Maintain record drawings for the cathodic protection system throughout the installation of the equipment. Properly identify all items of equipment and material. Show the exact locations of all anodes, buried wires, cathodic protection test boxes, and insulating pipe flanges using dimensional ties to existing structures or survey monuments. Record all changes by using a red pen or red pencil on full-size drawings.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide cathodic protection system materials and equipment that are new, undamaged, and in the original packaging marked with the manufacturer's name or trademark. The materials and equipment shall be of the manufacturer's latest standard design and shall be fully compatible to provide a complete and functional cathodic protection system.

2.02 PREPACKAGED MAGNESIUM ANODES

A. Each high-potential magnesium anode shall have a nominal weight of 17 pounds, excluding backfill in accordance with ASTM B80 or B843. The anode shall be 25.75 inches long by 3.50 inches wide by 3.75 inches high.

B. Composition of the anode shall be as follows (per ASTM B843):

Component	Composition by Weight %
Aluminum	0.01 max
Manganese	0.50 to 1.30
Silicon	0.05 max
Copper	0.02 max
Nickel	0.001 max
Iron	0.03 max
Other Metallic Impurities (ea.)	0.05 max
Others (total)	0.30 max

Component	Composition by Weight %
Magnesium	Remainder

C. The 17-pound anodes shall be packaged in permeable fabric that is 25.75 inches in length by 3.50 by 3.75 inches in diameter.

D. The fabric for each 17-pound anode shall contain a minimum of 30 pounds of backfill. The backfill material shall have the following composition:
   1. Hydrated Gypsum: 75%
   2. Bentonite: 20%
   3. Sodium Sulfate: 5%

E. The anode and backfill shall be prepackaged into a single unit, as described in Section 2.02 A thru D. A minimum of 25 feet of AWG No. 8 stranded copper wire with HMWPE insulation (black) shall be attached to the anode. The wire shall be sufficient length to reach the termination point without splices. Wire-to-anode attachment shall be by silver solder and sealed to prevent any moisture penetration. The anode system shall be as manufactured by BK Corrosion or approved equal.

F. The anode's current capacity, as measured using the ASTM G97 standard test procedure, shall be minimum 480 amp-hours per pound. If anodes are of the cast type, the anode foundry or the anode retail supplier shall have a quality control program that includes random ASTM G97 testing. ASTM G97 current capacity tests shall be performed on randomly selected anodes at a minimum rate of 1 for every 2,500 anodes cast. Submit the ASTM G97 current capacity test results for the testing date that is closest to the production date of the anodes supplied for this project. All cast high-potential magnesium anodes shall bear a stamp with its foundry heat number for traceability.

2.03 CATHODIC PROTECTION TEST STATIONS

A. Flush-Mounted Test Stations
   1. The flush-mounted test station shall consist of a nonconductive terminal board mounted in a locking cast iron lid and collar (suitable for placement in heavy traffic areas) and a plastic shaft.
   2. The test box shall pass U.S. DOT H-20 roadway load test. The cast iron of the lid and collar shall meet or exceed ASTM A48 Class 25 specification. The test box lid shall be made of cast iron and painted yellow. The lid shall feature a cast-in pentagonal bolt to lock into the cast iron cover.
   3. The cast iron collar shall be at least 5-inches in diameter, 2.75 inches high with lugs cast inside to accept the locking lid and to accept a 1-inch cast iron repaving adapter with original lid.
   4. The plastic shaft shall be made of ABS (acrylonitrile butadiene styrene), 18 inches long, with a flared bottom—to resist sinking in soil and provide protection against wire damage. The plastic shaft shall have a minimum 3.25-inch inner diameter. The plastic shaft shall be riveted to the cast iron collar.
   5. The test block shall be made of nonconductive PVC (polyvinyl chloride) plastic or phenol-formaldehyde resin.
   6. The test station shall be set in a 24-inch by 24-inch by 6-inch-thick concrete slab.

7. Where the test station is used for sacrificial anodes, the anodes shall be connected through a 0.01-ohm shunt.
8. The test station shall be permanently labeled with the purpose, type, stationing, and pipeline.
9. The terminal board shall contain a minimum of five terminals—using 0.25-inch by 20-thread brass or stainless-steel machine screws and nuts. The terminal board shall fit into the lid using hangers cast inside the lid.
10. The flush-mounted test station shall be manufactured by CP Test Services, Cott Manufacturing, Inc., or approved equal.

B. Test Station Concrete
1. Install level on a compacted gravel base. Install a 24-inch long, 2-inch diameter PVC vertical test port in the bottom of the test box. Place a slip-on PVC cap on the test port. Use flexible conduit to protect cable insulation where it enters the test box.
2. In unpaved areas, provide a square reinforced concrete pad that is 24 inches by 24 inches, and 6 inches thick. Reinforcement shall be #4 bars, at 12 inches on center each way, in the center of the pad. Edges shall be provided with a 3/4-inch chamfer. To channel water away from the test station slope the concrete 2 percent from center.
3. In paved areas, provide a square reinforced concrete pad that is 24 inches by 24 inches, and 12 inches thick. Reinforcement shall be #4 bars, at 12 inches on center each way, in the center of the pad. To channel water away from the test station slope the concrete 2 percent from center.

C. Compression Wire Terminals
1. Test station terminal lugs shall be non-insulating, one-hole ring type, compression terminal lugs for a 0.25-inch bolt size. Compression terminals shall be specially manufactured for terminating copper cables at test stations. The terminals shall be copper or tin-coated copper, as manufactured by Burndy Corporation or approved equal.
2. Compression connectors shall be specially manufactured for terminating the copper cables at the test stations. The connectors shall be copper and shall be manufactured by Burndy Corporation or approved equal.

D. Current-Measuring Shunt
1. Test station shunts shall be constructed to fit the terminal posts for the specified test station or junction box. The resistance shall be 0.01 ohm with a current capacity of 8 amperes. The shunt shall be Model "Yellow", as manufactured by Cott Manufacturing Company or approved equal.

2.04 REFERENCE ELECTRODES

A. The reference electrode shall be a permanent copper/copper sulfate reference electrode (CSE) designed for a minimum 20-year life. The electrode shall have a 2-inch diameter by 12.75-inch-long Schedule 80 PVC body. Lead wire shall be of sufficient length to reach the test station terminals without splicing. The lead wire shall be attached to the electrode core with the manufacturer's standard connection. The connection shall be stronger than the wire. No splicing of the reference electrode lead wire shall be permitted under any circumstances. The reference electrode shall be Model “Stelth 7 Rocket”, as manufactured by Borin Manufacturing Company or approved equal.

2.05 PIPE LEAD AND JOINT BOND WIRE

A. All wiring shall be stranded copper wire of the AWG wire size and insulation color shown on the Drawings in accordance with ASTM B3, excluding wire provided with the magnesium anodes and reference electrodes.

B. Wire for bonded joints shall be single conductor, stranded copper with high molecular weight polyethylene (HMWPE) insulation (black). Wire size shall be AWG No. 2 for piping larger than 36-inch diameter, AWG No. 4 for 16-inch through 36-inch diameter piping, and AWG No. 6 for smaller than 16-inch diameter piping and all associated pipe fittings. A minimum of two bonding wires per joint shall be installed.

C. Pipeline test wires shall be single conductor, AWG No. 8 stranded copper wire with 600-volt HMWPE insulation, with colors as shown on the Drawings.

D. No wire splices shall be allowed unless prior written approval is given by the Corrosion Engineer.

2.06 THERMITE WELD EQUIPMENT AND MATERIALS

A. Thermite weld molds and charges shall be suitable for the sizes and types of materials and shapes encountered. Adapter sleeves shall be utilized for all thermite welds.

B. Typical size of the exothermic weld charge is 15 grams. The manufacturer shall be consulted for the proper charge size and material to be welded.

C. All welding materials and equipment shall be the product of a single manufacturer.

D. All exothermic welds shall have one wire per weld, with a minimum of 6-inches between welds.

2.07 COATING FOR THERMITE WELDS

A. Thermite welds to steel piping shall be coated with a prefabricated assembly, specifically designed for covering cathodic protection wire connections to piping and fittings. There shall be one weld per prefabricated assembly. The prefabricated assembly shall consist of the following components:

1. Top plastic sheet formed with an igloo-shaped dome and entry tunnel for the lead wire;
2. A special elastomeric compound in the plastic dome, firm enough to resist flow at normally encountered application and operating temperatures, but soft enough to mold itself around and completely cover the irregular welded profile;
3. A double row of parallel, flexible, serrations on each side of the dome to assist with conforming around small-diameter pipe; and
4. A base of black, unbacked, elastomeric tape with exceptional adhesive properties for bonding firmly to a surface, when used with the appropriate primer.

B. Caps shall be Model Handy Cap, as manufactured by Royston Laboratories Division or approved equal. The appropriate primer, as required by the elastomeric cap manufacturer, shall be used. Primer for the Royston Handy-Cap shall be Model Roybond 747 Primer, as manufactured by Royston.

2.08 INSULATING FLANGE COMPONENTS

A. For purposes of this specification, the terms “Pipe Flange Insulating Kit”, “Insulated Flange”, “Insulated Joint”, and “Dielectric Flange” are used synonymously. “Isolation” may be substituted for “insulation”.

B. Pipe flange insulating kit materials shall be designated by the manufacturer as suitable for service at the operating temperatures and pressures for the pipeline.

C. Flange insulating kits shall consist of: a one-piece, full-face, insulating gasket; an insulating sleeve for each bolt; insulating washers; and steel washers. For nominal pipe diameters up to, and including, 36 inches, provide one insulating washer and one steel washer on each side of the flange for each flange bolt. For nominal pipe diameters greater than 36 inches, the insulating washers shall be installed sandwiched between a pair of matching steel washers on each side of the flange for each flange bolt.

D. Insulating Gasket: Insulating gasket retainers shall be full-face, Type E, NEMA G-10 glass, reinforced epoxy retainers with an ethylene propylene diene monomer (EPDM) rubber rectangular cross section O-ring seal. Minimum total gasket thickness shall be at least 1/8 inch. The gasket shall have the same outside diameter as the pipe flange. At valve-to-pipe connections where the inside diameters are not equal, the gasket’s inside diameter shall be equal to the smaller of the two inside diameters. Dielectric strength shall be at least 550 volts per mil in accordance with ASTM D149, and compressive strength shall be not less than 50,000 psi. The manufacturer’s name and date of manufacture shall be marked on both sides of the gasket with a minimum of 2-inch tall block letters using a durable marking ink or paint. The gasket shall be installed within six months of its manufacture date. Do not store insulated flange gaskets under direct sunlight nor at temperatures exceeding 110 degrees Fahrenheit. Use PSI Linebacker insulating gasket or approved equal.

E. Insulating Sleeves: Provide full-length, one-piece, NEMA G-10 glass-reinforced epoxy insulating flange bolt sleeves. Dielectric strength shall be at least 400 volts per mil, in accordance with ASTM D257. The length of the insulating sleeves shall provide an air gap between the end of the insulating sleeve and the inside surface of the stud bolt nut with a tolerance of 1/32 inch minimum and 1/8 inch maximum. Insulating sleeve length must be adjusted for the actual thickness of the steel washers and insulating washers, in accordance with ASTM F436. The bolt holes on the opposing flanges shall be aligned so as not to pinch the insulating sleeve, which would result in electrical shorting of the two flanges.

F. Insulating Washers: Insulating washers shall be NEMA G-10 glass-reinforced epoxy with a minimum thickness of 1/8 inch. Dielectric strength shall not be less than 550 volts per mil, and compressive strength shall not be less than 50,000 psi. The insulating washer’s inside diameter shall be sized to fit over the insulating sleeve’s outside diameter.

G. Steel Washers: Provide hardened steel washers that conform to ASTM F436 for insulated flanges greater than 36 inches in nominal diameter. Double steel washers—four steel washers per flange bolt—are required for insulated flanges greater than 36 inches in nominal diameter. The inside and outside diameters of the steel washers shall match those of the insulating washers. The steel washers must be able to freely rotate around the insulating sleeve. Attention must be paid to the fit between the steel washers and the insulating sleeve in order to avoid the washers twisting and cracking the sleeves when the flange bolts are torqued.

H. Provide four extra insulating sleeves and eight extra insulating washers for each insulating flange upon successful inspection of the insulating flange by the OWNER's ENGINEER.

2.09 EXTERNAL COATING SYSTEM FOR INSULATING FLANGES

A. Insulating flanges shall receive an exterior wax tape wrapping in the field. The coating applicator must apply the coating by and following all manufacturer's application specifications for the coating system and per the guidance in AWWA 217. All components of the coating system shall be manufactured by a single supplier to assure compatibility of individual components. The coating system shall be manufactured by Trenton Corporation or approved equal.

B. Materials:
   1. Primer: A blend of microcrystalline wax, plasticizer, and corrosion inhibitors, which has a paste-like consistency and is designed to displace moisture, penetrate rust and wet the surface, ensuring adhesion of the tape. The primer shall be Trenton Wax-Tape Primer or approved equal.
   2. Filler Putty: A cold-applied, anti-corrosive, moldable filler material used to even the contours of irregular fittings and surfaces. Filler putty shall be used at all irregular surfaces to provide a smooth surface for the application of the inner-wrap and outer-wrap, and shall have the following properties:
      a. Specific Gravity: 1.15
      b. Density: 24 cu. in. per lb.
      c. The filler putty shall be Trenton Fill-Putty or approved equal.
   3. Inner-Wrap: The inner-wrap shall be a non-woven, non-stitch-bonded, synthetic fabric saturated with a blend of microcrystalline wax, plasticizer, and corrosion inhibitor (no clay fillers). The inner-wrap shall have the following properties:
      a. Thickness: 70 to 90 mils
      b. Dielectric strength: 170 volts/mil
      c. The inner-wrap shall be Trenton #1 Wax-Tape or approved equal.
   4. Outer-Wrap: A white, resin-coated, woven fiberglass fabric. The outer-wrap shall have the following properties:
      a. Thickness: 0.005 inch
      b. Tensile strength (per 1-inch width): 85 lb. minimum
      c. Tape width: 6 inches
      d. The outer-wrap shall be Trenton Glas-Wrap or approved equal.

2.10 INSULATING BLANKETS

A. Where stray currents or contact with unprotected metallic structures are anticipated installation of an insulating blanket may be required between the two interfering structures. The insulating blanket shall be a minimum 1/8-inch neoprene or butyl rubber. The blanket shall be installed midway between the two structures. The blanket shall be square or rectangular with sides 36 inches greater than the diameter of the larger structure.

2.11 ELECTRICAL TAPE

A. Electrical tape shall be a conformable, water-tight sealant having a dielectric strength of at least 15 kV for a 1/8-inch-thick layer.

B. Tape shall be Scotch 88 Vinyl Tape and Scotch C130 Rubber Tape or approved equal.

2.12 CABLE WARNING TAPE

A. Cable warning tape shall be polyethylene material, minimum 6 inches wide, red or yellow in color, and labeled "CAUTION - CATHODIC PROTECTION".

B. Tape shall be Terra Tape, as manufactured by Reef Industries or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. The Drawings are diagrammatic. The exact locations and routing of anodes, test stations, cables and conduits shall be governed by structural conditions and any physical interference. The final placement of the anodes and test stations shall be at the locations approved by the OWNER's ENGINEER and shall be marked on the record drawings. Where above-grade test stations are specified, OWNER's ENGINEER may approve or request a "flush-to-grade" test station configuration, in accordance with the Drawings.

B. All materials, workmanship and installation shall conform with all requirements of the legally constituted authority having jurisdiction. These authorities include, but are not limited to, the Federal, State, County, or City codes and regulations.

C. Unless otherwise indicated, install all materials in accordance with the manufacturers' recommendations and safety procedures, and as shown on the Drawings.

D. Where requirements of this section conflict with the manufacturer's recommendations, the manufacturer's recommendations shall take precedence.

E. All materials and equipment to be used in construction shall be stored in such a manner as to be protected from detrimental effects from the elements. If appropriate storage is not available, stack materials and equipment well above ground level and protect from the elements as needed.

3.02 THERMITE WELDING

A. All thermite welds shall be made as shown on the Drawings and in accordance with the manufacturer's recommendations using the proper combination of equipment for the material and wire size being welded.

B. Ensure that the area where the attachment is to be made is absolutely dry. Remove mill coating, dirt, grime and grease from the pipe or fitting surface at the weld location by wire brushing or by the use of suitable safety solvents. At the weld location, use a mechanical grinder to clean a 2.5-inch square area of the pipe or fitting surface to a bright shiny surface, free of all serious pits and flaws.

C. Prepare the wire for welding by ensuring the cable is absolutely dry. The cable shall be free of dirt, grease and other foreign products. Cut the cable in such a way as to avoid flattening or forcing out of round. To prevent deformation of the cable, cut the cable with cable cutters. Remove the insulation in a manner that will avoid damage to strands. Install adapter sleeves for all bonds and test wires prior to welding; either prefabricated factory sleeved joint bonds or bond wire with formed sleeves made in the field are acceptable. Hold the cable at an approximate 30-degree angle to the pipe surface when welding.

D. When the weld has cooled, remove the weld slag and test the weldment for strength by striking with a sharp, shearing blow using a 2-pound hammer, while pulling firmly on the wire. Remove unsound welds and make new welds at least 2 inches away. Thoroughly clean mold and mold covers after completion of each weld to assure that no slag will penetrate into the next weld.

E. After soundness of the weld has been verified, thoroughly clean with a stiff wire brush and apply primer over the entire weld area where the elastomeric cap will be placed. The elastomeric cap shall extend on all four sides beyond the cleaned area. Push the dome of the prefabricated cap, containing elastomeric material, firmly into weld area. Lift the wire away from the pipe and apply the elastomeric material completely around and underneath the wire. Push the wire back down on the pipe. Follow all manufacturer's instructions for installing prefabricated caps.

3.03 BONDED JOINTS

A. All non-welded pipe joints—including those on pipe, fittings, valves and branch connections intended to be cathodically protected, and except those specified to be insulated—shall be bonded as shown on the Drawings. All bond cables shall be thermite-welded to the pipe or fitting, as described in 3.02 above.

B. A minimum of two bonding wires per joint shall be installed.

3.04 PREPACKAGED MAGNESIUM ANODES

A. Prepackaged high-potential magnesium anodes shall be installed where indicated on the civil Drawings or in accordance with the Cathodic Protection Schedule. Each anode shall be placed a minimum of 18-inches from the pipeline. Provide a minimum of 10 feet of separation between anodes that are grouped and electrically connected together in a single termination point. Provide a minimum anode spacing of 5 feet from other pipelines. Prior to installation, remove all shipping covers from the anode. (Note: The prepackaging fabric for magnesium anodes shall not be removed.) Install the anodes in existing soils—free from rocks, roots, organic material, trash or other debris—and backfill with a minimum of 6 inches of native soil. Do not install the anodes in sand, rock or gravel backfill. After placement, but prior to backfilling, pre-soak the anodes with 5 gallons of water.

B. Each anode shall be lowered, using a sling or rope, into the hole/excavation site and placed vertically at the bottom of the hole. The anodes shall not be transported, lifted, or lowered into the excavation using the anode lead wires. Care shall be taken to ensure that the anode lead wire insulation is not damaged. Anodes with damaged lead wires or insulation shall be removed from the project and replaced.

C. Anode lead wire shall be long enough to reach the junction box or test station without splicing. Care shall be taken not to damage the lead wire throughout the installation and testing process.

D. Prior to connecting the anodes to the structure wires, the open circuit potential of each anode shall be measured. A voltage of –1.70 volts, or more negative, shall be obtained. If –1.70 volts are not obtained, further investigation shall be conducted to determine why the –1.70 volts have not been obtained. If required, replace the anode.

E. At anode test stations, anode lead wires shall be buried a minimum of 2 feet below grade. Handle wire with care. Route the anode wires to the junction box or test station, without splices, in a manner to prevent damage to the wires.

F. The metal portion of the anodes shall not contact the protected pipeline, except through the anode leads at termination points.

G. Where multiple anodes are installed, the anodes shall be installed with half on the left side and half on the right side of the pipeline. As looking upstream, the right-side anode leads shall be orange color coded and the left-side anode leads shall be black color coded.

H. All anode wires shall terminate at a or junction box or test station for testing and monitoring.

3.05 DIRECTLY CONNECTED ANODES

A. All galvanic anodes shall be connected to the pipeline through a junction box or test station. Direct connection of anodes to the pipeline shall not be permitted.

3.06 TEST STATIONS

A. The CONTRACTOR shall have responsibility for determining the correct test station type to install, based on the location, structural obstructions, roads, anodes, insulating flanges, etc. Test stations shall be installed so as to avoid being damaged or obstructing the normal operation of any equipment.

B. Install test stations at the locations indicated on the civil Drawings or in accordance with the Cathodic Protection Schedule. Test stations shall be located directly over the pipeline, except in areas that would place the test station in a roadway. If the Drawings or Cathodic Protection Schedule indicate a placement location that lands in a roadway, then locate the test station at the closest point, just off the edge of the road. If installing an offset from the pipeline, refer to the offset test station detail on the Drawings. Flush-mounted test stations can be installed in the roadway as an alternate method. All test stations shall be properly labeled to indicate that they are for cathodic protection.

C. Attach test wires to the pipeline as indicated, using the proper thermite welding equipment and charges specified for the wire size and respective pipe material. Follow all procedures as outlined in Section 3.02 above.

D. All test station wires shall be routed a minimum of 2 feet below finished grade. Maintain sufficient slack in the test wires so that the wires can extend a minimum of 18 inches beyond the test station. Connect the test wires to the test station terminal block with one-hole compression terminal lugs for a 0.25-inch bolt size. Install a shunt and a copper shorting strap to connect the anode leads to the pipe lead where indicated on the Drawings.

E. The test station wires shall be protected from damage where they enter the conduit below the concrete pad.

F. The test stations shall be set in poured concrete (2 feet on each side and 6 inches thick) and reinforced with #4 rebar.

G. Where offset test stations are utilized in roadways, the test wires shall be routed under the roadway to the test station through PVC electrical conduit.

3.07 TRENCHING AND BACKFILL FOR CATHODIC PROTECTION SYSTEMS

A. Complete excavations and trenching, regardless of the type, nature, or condition of materials encountered, as required to accomplish specified construction to lines and grades shown.

B. Take care to avoid damage to existing structures and utilities during excavating and trenching process. Contractor may modify location, as approved by the ENGINEER, to minimize possible damage to existing structures. Trenches shall be of uniform depth and width, level, smooth, and free of sharp objects.

C. Slope, shore, or brace excavations and trenches, in accordance with OSHA regulations, as necessary, to prevent caving during excavation in unstable material, and to protect adjacent structures, property, workers, and the public.

D. Install horizontal runs of PVC electrical conduit in trenches at a depth of 36 inches. Install plastic warning tape in a continuous manner at 12 inches above all horizontal runs.

E. Securely attach identification tags to all wires with nylon fasteners prior to backfilling operations.

F. Backfill trench with excavated backfill materials, if suitable. Suitable backfill shall be free of angular rock, debris, roots, turf, or other deleterious materials.

G. Do not use backfill material of frozen or consolidated debris. Leave the trench with the excess backfill material neatly mounded at not more than 4 inches above the existing ground level for the entire width of the trench.

3.08 REFERENCE ELECTRODES

A. Install reference electrodes at the test stations, as indicated on the Cathodic Protection Schedule. The reference electrodes shall be installed between 12 inches to 18 inches from the pipe and at an approximate depth of 6 inches below pipe invert. Native trench material shall be used to backfill the reference electrodes for a minimum of 6 inches. Prior to installation, remove the plastic shipping cover from the reference electrode. The cloth bag containing the special backfill shall remain intact. Where one anode is installed the reference electrode shall be installed on the side of the pipeline opposite that of the anodes. Where multiple anodes are installed the reference electrode shall be placed a minimum of 10 feet from the closest anode

3.09 CLEARANCE TO OTHER STRUCTURES

A. Natural clearance of 18 inches between the pipeline and other structures shall be maintained where possible. If 18 inches of clearance cannot be maintained, then an insulating blanket shall be installed between the two structures.

3.10 INSULATING FLANGES

A. Insulating flanges shall be installed where shown on the Drawings. The CONTRACTOR shall carefully align and install the insulating components according to the insulator manufacturer's instructions. Before backfilling, the CONTRACTOR shall test each insulator for electrical isolation. If the flanges are not properly isolated, the CONTRACTOR shall, at their expense, repair or replace all defective components. The CONTRACTOR shall test the repaired insulating flange assembly. This process will continue until testing reveals that the flanges are properly isolated. Install test stations at all insulating flanges and insulating couplings as shown on the Drawings.

B. When the insulating flange kits are installed on an open-end flange, care shall be taken not to introduce any foreign material that could contaminate the interior surfaces for potable water in accordance with NSF 61.

3.11 COATING OF INSULATING FLANGES

A. The insulating flanges, including all isolation components, shall be tested for proper electrical isolation prior to applying the coating. The insulator shall be coated as described below.
   1. Clean the surface of the flange and all of its components by power tool cleaning, in accordance with the coating manufacturer's recommendations. If any part of the insulating flange kit is damaged while cleaning the metal components of the flange the damage part shall be replaced.
   2. Apply a uniform coat of the primer to the external surfaces of the insulator and all of its components, including bolts, nuts, etc. The primer shall extend a minimum of 12 inches on each side of the insulator.
   3. Apply filler mastic to all irregular surfaces of the insulator to ensure a smooth profile for application of the inner-wrap.
   4. Apply inner-wrap to the insulator and its components in a spiral fashion with a 50% minimum overlap. The inner-wrap shall extend a minimum of 12 inches on each side of the insulator.
   5. Apply outer-wrap to the insulator and its components in a spiral fashion with a 1-inch minimum overlap. The outer-wrap shall be applied with sufficient tension to provide continuous adhesion of the outer-wrap tape.

3.12 REINFORCED CONCRETE STRUCTURES

A. Under no circumstances shall metallic pipe be in contact with reinforcing steel.

B. Position reinforcing steel used in the construction of support blocks, anchor blocks, and any and all other concrete structures so that they are not in contact with the piping. Maintain a minimum clearance of 2 inches between the piping and all reinforcement steel or other metallic components. Under no circumstances shall metallic pipe be in contact with reinforcing steel, in accordance with NACE SP0286. If sufficient clearance cannot be provided, then an insulating blanket may be required between the pipe and reinforcing steel.

C. When penetrating a reinforced concrete slab (wall or floor), install a linked rubber seal between the pipe and the concrete slab sleeve. Install the linked rubber seal, in accordance with the manufacturer's requirements, to form direct contact to the concrete and to seal the area of the pipe penetration from water intrusion.

3.13 ISOLATION AND CONTINUITY TESTING

A. INSULATING FLANGES
   1. Test each insulated pipe flange in the presence of the Corrosion Engineer for effective electrical isolation of the two mating pipe flanges. Effectiveness of the insulated pipe flange shall be tested prior to backfilling in accordance with NACE SP0286, Section 8.2.7, using an insulation checker (e.g., M.C. Miller Gas Electronics Model 601, Tinker & Rasor RF-IT or approved equal).

B. CASINGS
   1. Test for electrical isolation between any metallic pipeline and metallic casing in accordance with NACE SP0286.

2. Prior to and upon completion of backfilling operations, test the electrical isolation between the pipeline and all casings the pipe passes through to ensure the casing is not electrically shorted to the pipeline. If the casing is found to be electrically shorted, or electrolytically coupled to the pipeline, the CONTRACTOR shall correct the deficiency at the CONTRACTOR's expense.

C. JOINT BONDING
   1. After installation, test all joint bonds to ensure the intended structures are electrically continuous.
   2. Where the pipeline is installed utilizing horizontal directional drilling (HDD), or any method other than open trench, the pipe section shall be tested for electrical continuity prior to connecting to the upstream and downstream pipe sections.
   3. The CONTRACTOR is responsible for the electrical continuity of pipe where the bonding is performed.

3.14 STRAY CURRENT MITIGATION

A. The CONTRACTOR's Corrosion Engineer and Cathodic Protection Technician shall conduct AC/DC stray current evaluations over the entire alignment.

B. A report shall be submitted detailing whether stray currents were found.

C. When AC/DC stray currents are either located or anticipated during construction, one or more of the following mitigation methods shall be employed:
   1. Installing strategically placed sacrificial anodes;
   2. Installing test wires for draining current through electrical bonds;
   3. Installing dielectric mats between the two pipelines;
   4. Increasing the distance between the two pipelines;
   5. Applying a high-quality, bonded coating to both pipelines;
   6. Utilizing nonmetallic pipeline material for the short section at the crossing;
   7. Installing metallic pipelines in nonmetallic casings.
   8. Modifying the design of the pipe to minimize susceptibility to stray currents; and
   9. Installing zinc grounding cells or solid-state devices.

D. The CONTRACTOR's Corrosion Engineer and Cathodic Protection Technician shall conduct a follow up stray current evaluation between 6 months and one year from construction completion.

3.15 CATHODIC PROTECTION SYSTEM ACTIVATION

A. The CONTRACTOR's Corrosion Engineer and Cathodic Protection Technician shall inspect, activate, and adjust the cathodic protection system in accordance with NACE TM0497. The Cathodic Protection Technician shall work under the direct supervision of a Corrosion Engineer, as defined by this specification.

B. The Corrosion Engineer shall evaluate whether there are any stray currents affecting the water pipeline. If stray currents are present and affecting the water pipeline, and if there is the possibility that the current can cause detrimental corrosion, then the cathodic protection system's performance shall be evaluated.

C. Do not proceed with the cathodic protection system activation until the reports for the following have all been submitted and accepted as complete by the OWNER's ENGINEER: Insulated Flange/Joint Inspection Report; Electrical Isolation Testing Between Pipe and Steel Reinforcement Report; and Baseline (Native) Potential Survey Report. Provide a minimum of five days' advance notice to the OWNER's ENGINEER before the cathodic protection activation will be performed to allow for coordination and observance of these tests.

D. Before beginning each day of testing, calibrate portable copper/copper sulfate reference electrodes with respect to a master reference copper/copper sulfate reference electrode.

E. Measure and record native pipe-to-soil potentials (i.e., baseline pipe-to-soil potentials) at all cathodic protection test stations prior to activating the cathodic protection system. Measure native potentials on both sides of all insulating flanges, at the dielectric unions and at all test station wires. Measure the native potentials of electrically grounded equipment inside all vaults and structures along the pipeline. Where two wires are attached to the same pipeline, measure and record the native potentials for both wires. If the potential measurements for the same pipeline differ by more than 5 millivolts, investigate the cause. All test measurements shall be in accordance with NACE TM497.

F. At test stations constructed with buried copper/copper sulfate reference electrodes (i.e., stationary reference electrodes), measure and record native potentials of the pipeline using both the stationary reference electrode and a portable copper/copper sulfate reference electrode before the cathodic protection system is activated.

G. Measure the potentials of all galvanic anodes before they are connected to the pipe. Verify that the open-circuit potential of each high-potential magnesium anode is more electro-negative than –1,700 millivolts. While making these measurements, place the copper/copper sulfate reference electrode in the soil directly over the anode hole. If an electro-negative potential -1,700 millivolts cannot be obtained a minimum of 24 hours shall be allowed before obtaining these measurements.

H. Activate the cathodic protection system by connecting all of the anode wires to the terminals inside each test station.

I. Measure and record "On" potentials at the same locations where native potentials were previously measured.

J. Measure and record the initial current of each anode groundbed using a portable digital meter. Measure and record the individual anode current outputs. Next, bond the anode lead wires to the pipe lead wires and measure the "On" potentials.

K. Resurvey the cathodic protection system at least two weeks after the initial energization to allow for the development of the cathodic polarization process.

L. Use the most recent current output of each anode groundbed to calculate the anode replacement dates, assuming continued uniform current outputs and the appropriate anode alloy consumption rate. Assume an 85% utilization rate for all anode ingots.

M. Furnish all test results, including all potential readings, anode groundbed current readings, insulating flange test data, dates, and times. Reference all data to the pipeline name and station number from which it was taken/observed. Submit all data, along with a letter report, to the OWNER's ENGINEER. The letter report shall include a description of the test methods, analysis of the data, and conclusions about the cathodic protection system's effectiveness. Submit all data in a spreadsheet format compatible with Microsoft Excel. Submit data in both hard copy and electronic format.

N. Prior to substantial completion, the OWNER's ENGINEER shall perform post-installation testing of all cathodic protection components. The repair or replacement of any defective or improperly installed components shall be the sole responsibility of the CONTRACTOR. Any and all repairs or replacement of defective or improperly installed cathodic protection components shall be performed by the CONTRACTOR and at no additional cost to the OWNER.

3.16 ACCEPTANCE CRITERIA FOR WSP

A. The operation of the cathodic protection system shall be tested to ensure that all portions of the pipeline are provided a full level of corrosion protection. Additional required tests are as follows:
   1. Open-circuit potentials of the anodes as indicated herein.
   2. Electrical isolation of all structures not intended to be cathodically protected, to include, but not be limited to, reinforcing steel, pipe piers, pipe saddle supports, electronic sensors, electrically operated valves, etc.
   3. Electrical continuity of the pipeline along the entire alignment.
   4. Electrical continuity of all test wires from the pipe to the termination end of the wire.

B. The criteria used to evaluate the protection levels shall be as listed in NACE SP0169.

C. Workmanship furnished by the CONTRACTOR shall be guaranteed for two years.

END OF SECTION

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SECTION 26 43 13

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 GENERAL

1.01 DESCRIPTION

A. Surge Protective Devices (SPD) replaces the Transient Voltage Surge Suppressors (TVSS) based on the National Electrical Code requirements.

B. Scope:
   1. Provide SPD with electrical characteristics and ratings for service entrance equipment, switchgear, switchboards, motor control centers, and panelboards specified in the Division 26 electrical distribution equipment specification sections or indicated on the Drawings. Provide SPD with the same voltage, phase, 3 or 4 wire system as the host electrical equipment.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
   3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
   4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI / Underwriters Laboratories 1449 4th Edition	Surge Protective Devices
Underwriters Laboratories 1283 3rd Edition	Electromagnetic interference filter for noise attenuation
MIL STD 220A, Rev A, Change Notice #2	Method of Insertion Loss Measurement
C-UL	Canadian Underwriters Laboratories
ANSI / IEEE C62.41	IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

1.03 RELATED SPECIFICATIONS

A. Section 26 23 00 – Low-Voltage Switchgear

B. Section 26 24 16 – Panelboards

C. Section 26 21 16 – Low-Voltage Underground Electrical Service Entrance

D. Section 26 24 19 – Motor Control Centers

1.04 SUBMITTALS

A. The following information shall be submitted to the Engineer:
   1. Submittals and transmittal procedures for submittals are defined in Section 01 33 00. Submittals should be required for the following conditions:
      a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole.
      b. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
      c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
      d. Provide verification that the SPD complies with the required ANSI/UL 1449 listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL).
      e. Compliance: File number verified on UL's website or other NRTL's website, with the following information:
         1) Model number
         2) SPD Type
         3) System voltage, phases
         4) Protection modes
         5) Voltage Protection Rating (VPR)
         6) Nominal Discharge Current (In).
      f. Drawings showing unit dimensions, weights, installation instruction details, and wiring configuration for sidemount SPD mounted external to electrical assembly.

1.05 PRODUCT DATA

A. The following information shall be submitted:
   1. Final Record as-built drawings and information.

1.06 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. The manufacturer shall be ISO 9001 or ISO 9002 certified for the equipment specified herein.

C. The manufacturer shall have produced similar electrical equipment for a minimum period of five years.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions.

B. One copy of manufacturer's instructions shall be included with the equipment at time of shipment.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Operation and maintenance manuals shall be provided with each SPD shipped.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The listing of manufacturers does not imply acceptance of products that do not meet the specified ratings, features, and functions. Manufacturers listed shall meet the specifications in their entirety.

B. Products in compliance with the specification and manufactured by others not named will be considered if pre-approved by the Engineer ten days prior to bid date.
   1. ABB
   2. Eaton Cutler-Hammer
   3. General Electric
   4. Siemens
   5. Accepted equal

2.02 SURGE PROTECTIVE DEVICES

A. Electrical Requirements:
   1. Refer to drawings for operating voltage and unit configuration.
   2. Maximum Continuous Operating Voltage (MCOV):
      a. Not be less than 125% of the nominal system operating voltage.

3. SPD suppression system include thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and other distribution levels.
4. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may lead to system upset or create environmental hazards.
5. SPD shall protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection modes			
Configuration	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

6. Nominal Discharge Current (In):
   a. SPDs applied to the distribution system shall have a 20kA In rating that include Types 1 and 2 or operating voltage. SPD's with "In" that is less than 20kA, shall be rejected.
7. Voltage Protection Rating (VPR): The maximum VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

B. Surge Protective Device Design:
   1. SPD's containing replaceable modules, replaceable fuses, replaceable batteries, requiring maintenance, or requiring diagnostic test kit shall not be accepted.
   2. Balanced Suppression Platform:
      a. The surge current shall be equally distributed to MOV components for equal stressing with equal impedance paths to each matched MOV.
   3. Electrical Noise Filter:
      a. EMI/RFI noise rejection filter for noise attenuation of line noise of 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method.
   4. Internal Connections:
      a. Plug-in component modules or printed circuit boards shall not be used as surge current conductors. Components shall be soldered, hardwired with connections utilizing low impedance conductors.

5. Monitoring Diagnostics:
    a. SPD monitoring:
        1) Status:
            a) Green/red solid-state indicator light for status of the protection on each phase.
                (1) For wye configured units, provide indicator lights for status of protection elements and circuitry in the L-N and L-G modes and in the N-G mode.
                (2) For delta configured units, provide indicator lights status of protection elements and circuitry in the L-G and L-L modes.
                (3) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode.
                (4) Status indicators indicate the protection on each phase or mode. If power is removed from any one phase, the indicator lights shall indicate the status of the protection on other phases and protection modes.
            b) Remote Alarm:
                (1) Provide Form C dry contacts (one NO and one NC) for remote annunciation. Both contacts change state under fault condition.
            c) Audible Alarm and Silence Button:
                (1) Audible alarm activates upon fault conditions. Alarm silence button silences the audible alarm.
            d) Surge Counter:
                (1) LCD display indicates number of surges and trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton allows the surge counter to be zeroed and contains a mechanism to prevent accidental resetting of the counter.
        2) Overcurrent Protection:
            a) The unit shall contain thermally protected MOVs shall disconnect the MOV(s) from the system during a thermal runaway condition.
        3) Design:
            a) SPD's components and diagnostics shall be contained within one discrete assembly.
        4) Safety Requirements:
            a) SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts.
            b) SPD's designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit and required conductors be factory installed.
            c) Sidemount SPD's shall be factory sealed in order to prevent access to the inside of the unit with factory installed phase, neutral, ground and remote alarm contacts shall have conductors protruding outside of the enclosure for field wiring.

2.03 SYSTEM APPLICATION

A. Minimum surge current capacity:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category

Category	Application	Per Phase	Per Mode
C	Service Entrance Locations, Switchboards, Switchgear, MCC, Main Entrance	240kA	120kA
	High Exposure Roof Top Locations and Distribution Panelboards	160 kA	80 kA
A	Branch Locations: Panelboards, MCCs, Busway	120 kA	60 kA

B. SPD's installed on the line side of the service entrance disconnect:
   1. Type 1.

C. SPD's installed on the load side of the service entrance disconnect:
   1. Type 1 or 2.

D. Panelboard Requirements:
   1. Where SPDs area required for panelboards, provide SPDs tested for application within ANSI/IEEE C62.41 Category B environments.
   2. SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
   3. SPD's installed following the load side of the main breaker and in main lug only panelboards installed following the incoming main lugs.
   4. SPD interfaced to the panelboard via a direct bus bar connection. Or SPD connected to a 30A circuit breaker for disconnecting purposes may be installed using short lengths of conductors integrally to the SPD and located directly adjacent to the 30A circuit breaker.
   5. SPD shall be mounted within the panelboard by the manufacturer.
   6. SPD shall be of the same manufacturer as the panelboard.
   7. Panelboard including the SPD shall be UL67 listed.

E. Switchgear, Switchboard, MCC and Busway Requirements:
   1. Where SPDs are required for switchgear, switchboard, MCCs, or busways, provide SPDs tested within ANSI/IEEE C62.41 Category C environments for service entrance locations
   2. SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, and busway.
   3. SPD shall be factory installed inside the switchgear, switchboard, MCC, and/or bus plug at the assembly point by the original equipment manufacturer.
   4. Locate SPD on the load side of the main disconnect device, close to the phase conductors and the ground/neutral bar.
   5. SPD connected through a disconnect (30A circuit breaker) located in immediate proximity to SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD shall be as short as possible per the factory specifications.
   6. Monitoring and diagnostic features shall be visible on the front of equipment.

F. Sidemount Mounting (SPD mounted external to electrical assembly):
   1. Lead length between the breaker and suppressor shall be short as possible.

2.04 ENCLOSURES

A. Where SPDs are mounted outside of electrical distribution equipment, provide SPDs in a dedicated enclosure of type in accordance with Section 26 05 33 – Raceways and Boxes for Electrical Systems.

PART 3 EXECUTION

3.01 GENERAL

A. Host equipment Manufacturer's representative shall visit the site, verify installation and testing, and verify that the SPD equipment and SPD installation meets intent of the Contract Documents and manufacturer's warranties and that the guarantees are in effect.

3.02 INSTALLATION

A. Install according to manufacturers recommendations.

B. Lead lengths shall not exceed manufactures recommendation.

C. Electrical equipment manufacturer shall authorize and perform bus taps connections, as necessary.

3.03 WARRANTY

A. The manufacturer shall provide a ten year warranty from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and applicable national or local code.

END OF SECTION

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SECTION 26 51 19

LED INTERIOR LIGHTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies light emitting diode (LED) indoor lighting fixtures, features and installation. Exterior LED lighting is specified in Section 26 56 19 LED Exterior Lighting.

B. Terminology used in this Section conforms to the following definitions: Nomenclature and Definitions for Illuminating Engineering Lighting terminology as defined in Illuminating Engineering Society IES RP-16-17.

1.02 QUALITY ASSURANCE

A. REFERENCE STANDARDS:

1. This Section incorporates by reference the latest revisions of the following documents as part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. References to documents shall are in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall be the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document, before it was discontinued.

Reference	Title
NFPA 70	National Electrical Code (NEC)

B. SPECIAL WARRANTY: Provide a Special Warranty for LED lightings that shall include the following:

1. The written 5-year on-site replacement includes parts, material, fixture finish and workmanship. Provide on-site fixture replacement includes transportation, removal, and installation of new products.
2. The fixture finish shall include failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
3. The replacement material warranty shall include defective or non-starting LED source assemblies and on power supply units.
4. The replacement warranty shall include lighting fixtures producing inadequately maintained illuminance levels at the end of the warranty period, as prorated from levels expected at end of useful life.
5. The warranty period shall begin on the date of Substantial Completion.
6. The Contractor shall provide the Owner with appropriate signed 5-year warranty certificates.
7. The Owner shall receive these certificates prior to final payment.

1.03 SUBMITTALS

A. PROCEDURES: Section 01 33 00 – Submittal Procedures.

B. ACTION SUBMITTAL ITEMS FOR THIS SECTION:

1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.
2. Manufacturer's descriptive catalog literature for all lighting fixtures and accessories being installed under this section. Catalog information describing fixture make, materials, and dimensions.
3. Information shall include manufacturer, wattage, voltage, mounting configuration, and lamp type. Catalog cuts shall be edited to show only the items, model numbers, and information which apply.
4. Submit applicable data as specified in Section 01 78 23 – Operation and Maintenance Data.
5. Lighting fixture model numbers are provided on the drawings in the lighting fixture schedule. The manufacturer's catalog numbers listed are examples of the basic model or series.
6. Referenced catalog numbers may not include voltage, mounting style, modifications, and other special features that are specified. The Contractor, supplier, and manufacturer shall provide the specified requirements.
7. The Contractor may propose an alternate luminaire for approval; however, sufficient information shall be provided as a part of the submittal for the Engineer and the Owner to review and compare the listed luminaire and the proposed alternate.
    a. The Contractor and lighting supplier shall provide a photometric, energy usage (efficiency), approvals/listings and materials comparison between the two fixtures.
    b. If an alternate lighting fixture layout is required, the Contractor and lighting fixture supplier shall provide all illuminance calculations as part of the submittal to verify minimum illuminance levels are met by the proposed revisions.
    c. Proposed alternates shall be shown to be equivalent or superior to the fixture listed. It shall be the Contractor’s responsibility to provide sufficient information to the Engineer and the Owner to verify and approve alternates.

PART 2 PRODUCTS

2.01 GENERAL

A. Lighting materials, including fixtures, accessories, and hardware, shall conform to the requirements specified on the Lighting Fixture Schedule on the project drawings.

B. Lighting fixtures shall be provided where shown on the drawings. The drawing’s light fixture placement is diagrammatical. The fixture layout shall be coordinated with the various trades to provide access to the fixture and to avoid installed equipment interference.

2.02 LIGHTING CONTROLS

A. Per Section 26 09 16 – Electrical Controls and Relays - that includes control switches, selector switches, relays, lighting contactors and other devices.

B. The project drawings indicate the operation and control methods and the circuits for the lighting systems.

2.03 LED LIGHTING

A. LED lighting shall be a functioning unit with all components including light source, lamps, power supply, control interface and components required for operation and shall be assembled by the lighting manufacturer or supplier.

B. Lighting fixtures shall be UL or ETL listed and labeled. Lighting testing shall be per IESNA LM-79 and LM-80 procedures.

C. Lighting fixtures shall comply with ANSI chromaticity standard for classifications of color temperature. Refer to the specified LED lamp color and color temperature or the manufacturer's literature.

D. LED drivers shall have reversed polarity protection, open circuit protection and require no minimum load. Drivers shall operate at a minimum 80 percent efficiency and have a class A noise rating.

E. Where LED systems are specified to be dimmable, the LED system shall be capable of full and continuous dimming.

PART 3 EXECUTION

3.01 GENERAL

A. The location and type of light fixtures and control are shown on the drawings.

B. Lighting circuit raceways and conductors shall be sized by the contractor, where the circuits are not shown on the drawings.

C. Raceways and wire shall be provided from the fixtures and switches to the lighting panel in accordance with the NEC.

D. Raceways shall be provided in accordance with Section 26 05 33 – Raceways and Boxes for Electrical Systems.

E. Circuit wire shall be provided in accordance with Section 26 05 19 – Low Voltage Power Conductors.

F. Fixtures labeled to require conductors with a temperature rating exceeding 75 degrees C shall be spliced to circuit conductors in a separately mounted junction box. Fixture shall be connected to junction box using flexible conduit with a temperature rating equal to that of the fixture.

G. Labels and marks, except the UL label, shall be removed from exposed parts of the fixtures. Fixtures shall be cleaned when the project is ready for acceptance.

H. Where recessed fixtures are required, the fixture shall be provided with mounting hardware for the ceiling system specified.

I. A concealed latch and hinge mechanism shall be provided for access to the lamps and ballasts and for removal and replacement of the diffuser without removing the fixture from ceiling panels.

J. Fixtures recessed in concrete shall have protective coating of bituminous paint.
   1. Fixtures shall be aligned and directed to illuminate an area as specified.
   2. Fixtures shall be directly and rigidly mounted on their supporting structures.
   3. Conduit system shall not be used to support fixtures.
   4. Where brackets or supports for lighting fixtures are welded to steel members, the welded area shall be treated with rust-resistant primer and finish paint.

K. Tighten electrical connectors and terminals according to manufacture's published torque-tightening values or use torque values specified in UL 486A and UL 486B.

L. Verify normal operation of each fixture.

M. Interrupt the power supply to demonstrate emergency lighting operation to battery power source or alternate power source. Retransfer to normal power supply.

N. Replace damaged fixtures.

3.02 LIGHTING FIXTURE SPECIFICATIONS

A. GENERAL: Lighting fixtures, including their related accessories, options, and hardware are specified on the drawings.

B. LIGHTING FIXTURE IDENTIFIER: Each lighting fixture type shown on the drawings may be identified with a unique acronym of two to four digits, as indicated below:
   1. FAMILY MEMBERS: Family members share the same primary physical characteristics, appearance, construction or function. The first digit as follows:
      a. A = Area light
      b. B = Bare lamp holder or strip light
      c. C = Corrosion-resistant
      d. D = Downlight
      e. E = Emergency
      f. F = Floodlight
      g. G = Grid mounted troffer
      h. H = Hazardous location
      i. I = Industrial
      j. L = Louver lens
      k. M = High/Low Bay
      l. N = Sign

m. O = Pool, or fountain, underwater
n. P = Patterned plastic lens
o. R = Roadway/parking lot
p. S = Suspended (architecturally finished areas)
q. T = Track-mounted
r. U = Under-cabinet
s. V = Vapor tight
t. W = Wraparound lens
u. X = Exit sign

2. LAMP SOURCES: The second digit of the fixture type indicates the lamp source from which the light is produced: L = Light Emitting Diode (LED)
3. OPTIONAL VARIANT: The third digit of the fixture type indicates variant of the same lighting type noted numerically.
4. Last Digit: Modifier to provide fixture information, as needed.

END OF SECTION

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SECTION 26 51 19.11

LED INTERIOR LIGHTING LIGHTSPEC

3.03 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	MF1
Fixture description:	High Bay LED Industrial pendant, high performance.
Construction:	Housing: Cast aluminum, integral heat sink. Sealed optic. Finish Color: Black
Electrical:	Input voltage: 277V, 254W Lamps: High performance 35,000 Lumen LED array, 3500K
Mounting :	Pendant.
Special Features:	Distribution: Wide. Control: 0-10V dimmable, motion sensor, Photocell, Wireless
Acceptable products:	Holophane LED High Bay Phuzion Series or equal.

3.04 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	MF1E
Fixture description:	High Bay LED Industrial pendant, high performance with emergency backup.
Construction:	Housing: Cast aluminum, integral heat sink. Sealed optic. Finish Color: Black
Electrical:	Input voltage: 277V, 254W Lamps: High performance 35,000 Lumen LED array, 3,500K
Mounting :	Pendant.
Special Features:	Distribution: Wide.
Acceptable products:	Holophane LED High Bay Phuzion Series or equal.

3.05 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	SF1
Fixture description:	Industrial Type LED, pendant industrial.
Construction:	Housing: 10 inch wide luminaire, 20-gauge steel, access plate on back of channel Finish: White.
Electrical:	Input voltage: 120V, 29W Lamps :48" LED, 4000 lumens, 3500°K, 80 CRI
Mounting:	Pendant, cable, chain.
Special :	Distribution: Spread downlight Molded UV-stabilized polycarbonate or acrylic diffuser, mounted with stainless steel cam latches.
Acceptable products:	Lithonia MSL LED Low Bay or equal.

3.06 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	SF1E
Fixture description:	Industrial Type LED, pendant industrial with emergency battery pack.
Construction:	Housing: 10 inch wide luminaire, 20-gauge steel, access plate on back of channel Finish: White.
Electrical:	Input voltage: 120V, 29W Lamps :48" LED, 4000 lumens, 3500°K, 80 CRI
Mounting:	Pendant, cable, chain.
Special :	Distribution: Spread downlight Molded UV-stabilized polycarbonate or acrylic diffuser, mounted with stainless steel cam latches.
Acceptable products:	Lithonia MSL LED Low Bay or equal.

3.07 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	X1
Fixture description:	LED exit sign with right arrow, red lettering, damp locations.
Construction:	Housing: ABS thermoplastic Finish Color: White Faceplate: Green lettering on black stencil.
Electrical:	Input voltage: Universal 120-277V Lamps: LED Battery: Nickel cadmium battery, 90 minutes minimum
Mounting:	Universal, top, end or back mounted.
Special features:	Meets UL924, NFPA 101
Acceptable products:	Dual Lite EVE Series or equal.

3.08 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	X2
Fixture description:	LED exit sign, no arrow, red lettering, damp locations.
Construction:	Housing: ABS thermoplastic Finish Color: White Faceplate: Green lettering on black stencil.
Electrical:	Input voltage: Universal 120-277V Lamps: LED Battery: Nickel cadmium battery, 90 minutes minimum
Mounting:	Universal, top, end or back mounted.
Special features:	Meets UL924, NFPA 101
Acceptable products:	Dual Lite EVE Series or equal.

3.09 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	X3
Fixture description:	LED exit sign with left arrow, red lettering, damp locations.
Construction:	Housing: ABS thermoplastic Finish Color: White Faceplate: Green lettering on black stencil.
Electrical:	Input voltage: Universal 120-277V Lamps: LED Battery: Nickel cadmium battery, 90 minutes minimum
Mounting:	Universal, top, end or back mounted.
Special features:	Meets UL924, NFPA 101
Acceptable products:	Dual Lite EVE Series or equal.

END OF SECTION

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SECTION 26 56 19

LED EXTERIOR LIGHTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies light emitting diode (LED) exterior lighting fixtures features and installation. Interior LED lighting is specified in Section 26 51 19 LED Interior Lighting.

B. Terminology used in this Section conforms to the following definitions: Nomenclature and Definitions for Illuminating Engineering Lighting terminology as defined in Illuminating Engineering Society IES RP-16-17.

1.02 QUALITY ASSURANCE

A. REFERENCE STANDARDS:

1. This Section incorporates by reference the latest revisions of the following documents as part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. References to documents shall are in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall be the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document, before it was discontinued.

Reference	Title
NFPA 70	National Electrical Code (NEC)

B. SPECIAL WARRANTY: Provide a Special Warranty for LED lighting that shall include the following:

1. The written 5-year on-site replacement includes parts, material, fixture finish and workmanship. Provide on-site fixture replacement includes transportation, removal, and installation of new products.
2. The fixture finish shall include failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
3. The replacement material warranty shall include defective or non-starting LED source assemblies and on power supply units.
4. The replacement warranty shall include lighting fixtures producing inadequately maintained illuminance levels at the end of the warranty period, as prorated from levels expected at end of useful life.
5. The warranty period shall begin on the date of Substantial Completion.
6. The Contractor shall provide the Owner with appropriate signed 5-year warranty certificates.
7. The Owner shall receive these certificates prior to final payment.

1.03 SUBMITTALS

A. PROCEDURES: Section 01 33 00 – Submittal Procedures.

B. ACTION SUBMITTAL ITEMS FOR THIS SECTION:

1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.
2. Manufacturer's descriptive catalog literature for all lighting fixtures and accessories being installed under this section. Catalog information describing fixture make, materials, and dimensions.
3. Information shall include manufacturer, wattage, voltage, mounting configuration, and lamp type. Catalog cuts shall be edited to show only the items, model numbers, and information which apply.
4. Submit applicable data as specified in Section 01 78 23 – Operation and Maintenance Data.
5. Lighting fixture model numbers are provided on the drawings in the lighting fixture schedule. The manufacturer's catalog numbers listed are examples of the basic model or series.
6. Referenced catalog numbers may not include voltage, mounting style, modifications, and other special features that are specified. The Contractor, supplier, and manufacturer shall provide the specified requirements.
7. The Contractor may propose an alternate fixture for approval; however, sufficient information shall be provided as a part of the submittal for the Engineer and the Owner to review and compare the listed luminaire and the proposed alternate.
    a. The Contractor and lighting supplier shall provide a photometric, energy usage (efficiency), approvals/listings and materials comparison between the two fixtures.
    b. If an alternate lighting fixture layout is required, the Contractor and lighting fixture supplier shall provide all illuminance calculations as part of the submittal to verify minimum illuminance levels are met by the proposed revisions.
    c. Proposed alternates shall be shown to be equivalent or superior to the fixture listed. It shall be the Contractor’s responsibility to provide sufficient information to the Engineer and the Owner to verify and approve alternates.

PART 2 PRODUCTS

2.01 GENERAL

A. Lighting materials, including fixtures, accessories, and hardware, shall conform to the requirements specified on the Lighting Fixture Schedule on the project drawings.

B. Lighting fixtures shall be provided where shown on the drawings. The drawing’s light fixture placement is diagrammatical. The fixture layout shall be coordinated with the various trades to provide access to the fixture and to avoid installed equipment interference.

2.02 EXTERIOR LIGHTING POLES

A. Provide lighting poles with pole cap, hand holes, ground lug, and the necessary fixture mounting hardware.

B. TYPE:
   1. Site/Area poles as shown on the contract drawings:
      a. Shape: round, square, tapered, straight
      b. Material: Steel, concrete, aluminum, wood
      c. Finish: galvanized, powder coated
      d. Height: 6', 10', 15', 20', 30' examples
      e. Options: tall pole breakaway, selector switch such as HOA where Auto mode may be a photo cell, and GFI receptacle may also be required on a pole where shown.
   2. Stanchion poles:
      a. In Class I, Div. 1 areas provide pole as detailed and specified on the drawings.
      b. In Class I, Div. 2 and unclassified areas provide a telescoping light pole. Pole shall meet the sub-sequent requirements.
      c. Construction:
         1) Telescoping; factory sealed and pre-wired
         2) Adjustable 360 deg. pole rotation
         3) Adjustable height
         4) Spring assist for controlled lowering and assist to raise
      d. Height: As shown; adjustable raised height
      e. Certifications:
         1) UL 1598
         2) CSA C22.2 No. 250.0-08
         3) Suitable for use in Class I, Division 2 and Class I, Zone 2 areas
      f. Wind Rating: AASHTO standard; 310 mph aluminum; 230 mph stainless steel
      g. Vibration: IEC 60068-2-6
      h. Material: Aluminum T6061 or Stainless Steel 316 grade, as specified
      i. Hardware: Xylan 1400 coated for corrosion protection
      j. Cable:
         1) 12/3 AWG UL/CSA Listed
         2) 600V, -40 deg C to 105 deg C
         3) Sun and oil resistant
         4) ROHS II Reach
         5) Internal conduit for cable protection
      k. System shall be factory assembled and wired
      l. Coordinate with fixture mounting requirements
      m. Poles shall not to be handrail mounted
      n. Pole shall be Eaton/Crouse Hinds V-Spring system or approved equal.

o. Model V65BA –A; top hat and fitting mounts shall be provided as required for fixtures;
p. Provide optional “J” bolts as required for wind requirements in the area.

2.03 SITE JUNCTION BOXES

A. Provide a minimum of one junction box for the distribution of outdoor lighting circuits within ten feet of building and as required. Boxes shall be precast concrete, set flush with the ground. Size shall be approximately 10 x 16 x 12 inches deep.

B. Lid shall be cast iron with permanent inscription: "LIGHTING". Boxes shall be Brooks Products, Oldcastle Precast, Forni Corporation, Utility Vault Company, Christy Concrete Products, or equal.

C. Examples: Jensen Precast Pull Boxes 10” x 17”, Oldcastle, Brooks Products, Christy, J&R, Caltrans. HT = High Traffic Pull Box.

D. Circuit’s raceways and conductors shall be terminated and spliced, respectively at new junction box. Provide watertight U.L. Listed splices for the circuits.

2.04 PHOTOELECTRIC CELL UNITS

A. Photoelectric cell units shall in a plug receptacle assembly.

B. The plug receptacle assembly shall be three-prong polarized locking type.

C. Assembly shall be suitable for outdoor mounting.

2.05 LIGHTING CONTROLS

A. Per Section 26 09 16 – Electrical Controls and Relays - that includes control switches, selector switches, relays, lighting contactors and other devices.

B. The project drawings indicate the operation and control methods and the circuits for the lighting systems.

2.06 LED LIGHTING

A. LED lighting shall be a functioning unit with all components including light source, lamps, power supply, control interface and components required for operation and shall be assembled by the lighting manufacturer or supplier.

B. Lighting fixtures shall be UL or ETL listed and labeled. Lighting testing shall be per IESNA LM-79 AND LM-80 procedures.

C. Lighting fixtures shall comply with ANSI chromaticity standard for classifications of color temperature. Refer to the specified LED lamp color and color temperature or the manufacturer’s literature.

D. LED drivers shall have reversed polarity protection, open circuit protection and require no minimum load. Drivers shall operate at a minimum 80 percent efficiency and have a class A noise rating.

PART 3 EXECUTION

3.01 GENERAL

A. The location and type of light fixtures and control are shown on the drawings.

B. Lighting circuit raceways and conductors shall be sized by the contractor, where the circuits are not shown on the drawings.

C. Raceways and wire shall be provided from the fixtures and switches to the lighting panel in accordance with the NEC.

D. Raceways shall be provided in accordance with Section 26 05 33 – Raceways and Boxes for Electrical Systems.

E. Circuit wire shall be provided in accordance with Section 26 05 19 – Low Voltage Power Conductors.

F. Fixtures labeled to require conductors with a temperature rating exceeding 75 degrees C shall be spliced to circuit conductors in a separately mounted junction box. Fixture shall be connected to junction box using flexible conduit with a temperature rating equal to that of the fixture.

G. Photoelectric cells, where specified, shall be oriented toward the north.

H. Labels and marks, except the UL label, shall be removed from exposed parts of the fixtures. Fixtures shall be cleaned when the project is ready for acceptance.

I. A concealed latch and hinge mechanism shall be provided for access to the lamps and ballasts and for removal and replacement of the diffuser without removing the fixture.

J. Fixtures recessed in concrete shall have protective coating of bituminous paint.
   1. Fixtures shall be aligned and directed to illuminate an area as specified.
   2. Fixtures shall be directly and rigidly mounted on their supporting structures.
   3. Conduit system shall not be used to support fixtures.
   4. Where brackets or supports for lighting fixtures are welded to steel members, the welded area shall be treated with rust-resistant primer and finish paint.

K. Underground and outdoor wire splices shall be in accordance with Section 26 05 19.

L. Tighten electrical connectors and terminals according to manufacture's published torque-tightening values or use torque values specified in UL 486A and UL 486B.

M. Verify normal operation of each fixture.

N. Interrupt the power supply to demonstrate emergency lighting operation to battery power source or alternate power source. Retransfer to normal power supply.

O. Replace damaged fixtures.

3.02 LIGHTING FIXTURE SPECIFICATIONS

A. GENERAL: Lighting fixtures, including their related accessories, options, and hardware are specified on the drawings.

B. LIGHTING FIXTURE IDENTIFIER: Each lighting fixture type shown on the drawings may be identified with a unique acronym of two to four digits, as indicated below:

1. FAMILY MEMBERS: Family members share the same primary physical characteristics, appearance, construction or function. The first digit as follows:
    a. A = Area light
    b. B = Bare lamp holder or strip light
    c. C = Corrosion-resistant
    d. D = Downlight
    e. E = Emergency
    f. F = Floodlight
    g. G = Grid mounted troffer
    h. H = Hazardous location
    i. I = Industrial
    j. L = Louver lens
    k. M = High/Low Bay
    l. N = Sign
    m. O = Pool, or fountain, underwater
    n. P = Patterned plastic lens
    o. R = Roadway/parking lot
    p. S = Suspended (architecturally finished areas)
    q. T = Track-mounted
    r. U = Under-cabinet
    s. V = Vapor tight
    t. W = Wraparound lens
    u. X = Exit sign
2. LAMP SOURCES: The second digit of the fixture type indicates the lamp source from which the light is produced: L = Light Emitting Diode (LED)
3. OPTIONAL VARIANT: The third digit of the fixture type indicates variant of the same luminaire type noted numerically.
4. Last Digit: Modifier to provide fixture information, as needed.

END OF SECTION

SECTION 26 56 19.11

LED EXTERIOR LIGHTING LIGHTSPEC

3.03 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	AF1
Fixture description:	LED trapezoidal wedge mini sconce
Construction:	Housing: Die-cast aluminum, with black finish
Lighting:	Distribution: Type IV throw Alt. Source: Emergency battery back-up with surface adapter.
Electrical:	Input voltage: 120VAC Lamps: 39W LED array, 4,000°K
Mounting:	Wall
Special features:	Surge protector, 0-10VDC dimming
Acceptable products:	Signify Gardco 111L, or equal.

3.04 LIGHTING FIXTURE SPECIFICATION SHEET–LIGHTSPEC

Identifier:	A1
Fixture description:	LED outdoor light pole area luminaire, wet locations
Construction:	Housing: die cast aluminum, NEMA 4X (IP66) construction
Electrical:	Input voltage: Universal 120-277VAC. Lamps: 305W LED array, 3000°K, 43,000 Lumens
Mounting:	Adjustable knuckle mount option, yoke mount option
Special features:	Distribution: general area diffused by prismatic globe. Prismatic glass globe with guard.
Acceptable products:	Holophane Predator Medium LED or equal.

END OF SECTION

SECTION 28 10 00

ACCESS CONTROL AND MONITORING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the final design, provision, supervision, and installation of a complete, operable, programmed, and tested intrusion and access control system by a qualified firm specializing in access control and monitoring system (ACAMS) installation. Work includes the design and installation of cable and raceway systems to support the ACAMS monitoring, control, and alarm devices. The ACAMS qualified firm shall assume unit responsibility for all aspects of the ACAMS.

B. The provided system shall be fully new system installed at the City Creek Water Treatment Plant (CCWTP). Contractor shall coordinate all system components with the Officer-in-Charge to confirm compatibility and integration.

1.02 QUALITY ASSURANCE

A. Reference Standards:
   1. This Section incorporates, by reference, the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
      a. NFPA 70 National Electrical Code (NEC)
      b. UL 464 Audible Signaling Appliances
      c. UL 294 ALVY: Access Control Systems Unit
      d. UL 681 Standard for Installation of Burglar Alarm Systems
      e. UL 683 Intrusion Detection Units
   3. This Section references other sections with associated work specified therein:
      a. Sections in Div. 26 specify raceways, conductors, and device requirements.

B. Listed Products:
   1. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose per Div. 26 specifications, or UL recognized.

C. Unit Responsibility:
   1. The Contractor, in conjunction and coordination with the security Contractor specified in this Section, shall integrate all new video cameras into the existing video management system.

D. Contractor Requirements:
   1. The security Contractors are pre-qualified by CCWTP to perform the work specified in this section without the need to provide Evidence of Experience. CCWTP shall provide a list of said Contractors.
   2. The security Contractor shall be a licensed security contractor with a minimum of five (5) years experience installing and servicing systems of similar scope and complexity. The Contractor shall provide three (3) current references from clients with systems of similar scope and complexity which became operational in the past three (3) years. The technicians shall have a minimum of three (3) continuous years of technical experience in electronic security systems.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 26 05 00.

1.04 SUBMITTALS

A. General:
   1. Submittals and transmittal procedures for submittals are defined in Section 01 33 00. Submit in accordance with the procedures set forth in the General Conditions of the Contract Documents and Section 01 33 00 that include drawings, information and technical data for equipment and as required in Section 26 05 00.

B. Action Submittals:
   1. Package 1:
      a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
         1) Section 01 79 00 – Demonstration and Training
         2) Section 01 78 23 – Operating and Maintenance Data
         3) Section 26 05 00 – Common Work Results for Electrical
         4) A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
         5) The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
         6) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

b. A copy of the contract document instrumentation network diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

c. A copy of the contract document electrical plan drawings, sections, and details showing sensor installation locations and details. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

d. Contractor or security sub-Contractor experience and resumes for the personnel installing the cameras and integrating them into the Owner's existing video management system. Include factory training certifications.

2. Package 2:

a. Marked product literature of all cameras, mounting hardware, cable junction boxes, and accessories to be provided.

b. Installation drawings for only the camera equipment and mounting accessories to be provided. Drawings shall include:

1) Floor plan drawing(s) and riser diagram(s) showing intended installation locations of cameras along with mounting hardware, brackets, poles/stanchions, base plates, cable junction boxes, and other necessary appurtenances for a complete installation.

2) Complete interconnection diagram(s) of all cameras with their associated junction boxes, including wiring, terminations, and details of interconnection to data transmission media and data communication network.

3) Details of surge protection device installation.

c. Coordination drawings:

1) Floor plans, elevations, and details indicating all floor, wall, and ceiling penetrations.

d. List of miscellaneous items, cables, spare parts, that will be provided.

C. Closeout Submittals:

1. BRIC Package:

a. Final reviewed submittal, including revised as-built submittal drawings.

b. Manufacturer's operation and maintenance information, edited for this project, as specified in Section 01 78 23.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND ACCCEPTABLE PRODUCTS

A. All access control equipment and devices shall be compatible with the new ACAMS server.

B. Latest versions of Mercury Security LP1502 series Intelligent Controllers (or approved equal).

C. Latest versions of Mercury Security MR52 2-door interface module, or approved equal.

D. Latest versions of HID RP40, or approved equal.

E. ACAMS supplier shall have sufficient products available and shall have an available service organization for seven-days-a-week technical support for throughout the ACAMS warranty.

2.02 SYSTEM DESCRIPTION

A. The Contract Drawings are diagrammatic in nature and are subject to change due to requirements of the favorably reviewed ACAMS submittal and actual field conditions. ACAMS control panels are located on the plan drawings. The Contractor shall design and install the system cable and raceway system to connect the ACAMS devices to the ACAMS control panels and to interconnect the system panels.

B. The System shall be a microprocessor-based network system with the ACAMS control panel assemblies and connected devices designed and manufactured by the same company and tested for a fully functioning system.

C. Equipment, materials, accessories, devices shall be provided by a single manufacturer where possible. Equipment provided by different manufacturers shall be recognized as system compatible by both manufacturers, and “Listed” as such by Underwriters Laboratories (UL).

D. System shall allow authorized service personnel using a program/service tool or laptop computer to change the configuration of the ACAMS control panels to meet changes in building layout or environment. System changes by the manufacturer’s representative, including hardware additions or deletions, shall be documented, and Record As-built drawings shall be submitted upon completion.

2.03 ACCESS CONTROL SYSTEM COMPONENTS

A. The ACAMS for the plant shall be compatible and integrated with a new access control server. Where specified on the Contract Drawings, each building shall have one or more Mercury Security LP1502 series (or higher model) Intelligent Controllers that is networked to the ACAMS and shall coordinate the access control for the card reader devices installed at the building. These networked controllers shall be installed in an enclosure with appropriate power supplies. The networked controllers shall be extended by appropriate Mercury Security MR52 2-door interface modules located in enclosures near the door(s) assigned to the module. A backup battery system shall be provided for each control panel housing networked controllers. Remote devices including card reader devices, electrified door locks or electric door strikes, and door switches shall be interconnected to the door interface modules and/or networked controllers as required to provide an integrated, fully-functional ACAMS. Contractor to relay wiring information to CVWRF such as input, output, card reader connection locations on the control boards.

B. MAIN CONTROLLER:

1. The networked controller shall be Ethernet-enabled and provided with a built-in feature-set whose capabilities include Access Control, Intrusion Detection, and Card Reader monitoring.

2. The networked controller shall include the following features and capabilities:
    a. Support for 240,000 identities (cardholders)
    b. Support for 32 access levels per cardholder
    c. 50,000 transaction buffer
    d. Management for up to 64 doors
    e. One 10/100 Mbps ethernet port
    f. RS-485 (2-wire) port for networking of door interface modules
    g. Power requirements: 12 - 24 VDC, 500 mA
    h. Fully configurable via Genetec Security Center 5.7 web browser interface
    i. Open Supervised Device Protocol (OSDP) compliant
    j. 4 form C relay outputs rated 5A @ 30 VDC
    k. 8 general purpose programmable inputs
    l. UL 294 recognized
    m. Anti-pass back support with nested area, hard, soft, or timed forgiveness
3. Manufacturer/model: Mercury Security LP1502 series Intelligent Controller (or higher), or approved equal.

C. DOOR INTERFACE MODULE:
1. The door interface module shall provide an interface for the card reader, door contact, and electric strike/lock control.
2. The door interface module shall include the following features and capabilities:
    a. RS-485 (2-wire) communication with networked controller.
    b. Power requirements: 12 - 24 VDC, 550 mA maximum
    c. 6 relay form C relay outputs rated 5A @ 28 VDC
3. Manufacturer/model: Mercury Security MR52 2-door interface module, or approved equal.

D. REQUEST-TO-EXIT SENSOR: (NOT USED)

E. CARD READER:
1. The card reader shall provide access request to the system from individual points of physical entry via smart card technology.
2. Card readers shall be provided with the following features and functions:
    a. Compatible with CVWRF existing access security cards.
    b. Compatible with both industry standard 125 kHz proximity detection and 13.56 MHz contactless technologies, including MIFARE DESFIre EVI.
    c. Dual-state LED (red, green) visual indication and audio feedback representing the status and activity information.
    d. Optical tamper configured to alarm when mounting plate is removed.
    e. Housing material: UL94 polycarbonate, black
    f. Power: 5 - 16 VDC
    g. EAL5+ Certified Secure Element Hardware that provides tamper-proof protection of keys/cryptographic operations.
    h. Lifetime warranty against defective materials and workmanship.

i. Mounting on standard single gang electrical box, suitable for wall mounting.
j. Output interface compatible with Wiegand (500 feet maximum length with 24 AWG and 300 feet with 24 AWG), Clock & Data, and RS-485 (maximum bus length of 4000 feet).

3. Manufacturer/model: HID RP40, or approved equal.

F. ELECTRIFIED DOOR LOCK:
1. The electrified door lock shall be coordinated with new and existing door types and door interface modules provided to ensure compatibility.
2. The electrified door lock power requirements shall be compatible with the ACAMS.
3. The electrified door shall be configured to be fail-safe in the event of power failure or equipment failure.
4. Door strike shall have fully sealed electronics, tamper proof, and weather proof.
5. Door strike shall have dual voltage options: 12VDC or 24VDC.
6. Manufacturer/model:
a. Securitron Magnalock M32/62/82B Series
b. Vista V2M1200/1290 Series Maglock
c. Or approved equal

G. ELECTRIC DOOR STRIKE:
1. Electrified door strike shall be compatible with the door latch hardware and listed by the door hardware manufacturer as being compatible. The door strike operating power requirements shall be compatible with the ACAMS.
2. Door strike shall have dual voltage options: 12VDC or 24VDC.
3. The electric door strike shall be configurable to be fail safe in the event of power failure or equipment failure.
a. Manufacturer/model: HES 9500/1500C /4500C Series
b. Or approved equal

H. DOOR CONTACT:
1. Door contacts shall be manufactured for installation in the door jam and incorporate non-powered (dry) switches with leads to connect to the monitoring equipment.
2. Door contacts shall be compatible with the ACAMS to provide door open/closed status.
3. Door contacts shall have lifetime warranty from manufacturer.
4. Manufacturer/model:
a. GRI 184-12
b. GRI 270-36
c. Or approved equal

I. POWER SUPPLY AND CHARGER, ENCLOSURES, AND BATTERY BACKUP
1. Power supply shall be an integrated package consisting of a power-limited supply and a battery charger to maintain and charge the backup batteries.
2. The power supply and enclosure selected for a specific location shall be as indicated on the submitted shop drawings and sized appropriately for the ACAMS component loads.

3. Door interface module control panels: The power supply and enclosure shall include the following features:
    a. Supply that converts 120VAC to 12VDC or 24VDC power-limited output. Output voltage shall be switch-selectable. Minimum output rating shall be 4A at 12VDC and 3A at 24VDC. Outputs shall be filtered and electronically regulated to limit output voltage ripple to 100mV maximum.
    b. Steel enclosure with locking door, NEMA rated based on area type as specified in Section 25 05 00. Enclosure shall have space for installing a minimum of two door interface modules. The panels shall be wall mounted with enclosure containing power supplies with advanced power management features. The enclosure and power supply shall be certified for operating in an environment of -10° to +55° C (14° to 131° F) with 10 to 90% RHNC. The enclosure minimum size shall be 16" H x 12" W x 4.5" D.
    c. Incoming power (120VAC) switch.
    d. LED indicators for input and output status. (ON/OFF)
    e. Relay contact (Form C) output to indicate AC power fail.
    f. Relay contact (Form C) output to indicate Low Battery.
    g. Automatic switchover to back up battery power when AC power fails.
    h. Low battery disconnect.
    i. Thermal overload protection.
    j. Output side short circuit protection.
    k. Tamper switch.
    l. Manufacturer: Mercury Security dual-voltage integrated power supplies for Mercury Security door interface modules, or approved equal.
4. Main controller control panel: The enclosure and power supply provided for each networked controller control panel shall include the following features:
    a. Supply that converts 120VAC to 12VDC or 24VDC power-limited output. Output voltage shall be switch-selectable. Minimum output rating shall be 6A at 12VDC and at 24VDC. Outputs shall be filtered and electronically regulated to limit output voltage ripple to 100mV maximum.
    b. Power limited distribution panel.
    c. Steel enclosure with locking door, NEMA rated based on area type as specified in Section 25 05 00. Enclosure shall have space for installing a minimum of two networked controllers. The panels shall be wall mounted with enclosure containing power supplies with advanced power management features. The enclosure and power supply shall be certified for operating in an environment of -10° to +55°C (14° to 131°F) with 10 to 90% RHNC. Enclosure minimum size shall be 42"H x 36" W x 8" D.
    d. Incoming power (120VAC) switch.
    e. LED indicators for input and output status. (ON/OFF)
    f. Relay contact (Form C) output to indicate AC power fail.
    g. Relay contact (Form C) output to indicate Low Battery.
    h. Automatic switchover to backup battery power when AC power fails.
    i. Low battery disconnect.
    j. Thermal overload protection.
    k. Output side short circuit protection.

l. Tamper switch.

m. Manufacturer: Mercury Security dual-voltage integrated power supplies for Mercury Security LP1502 series Intelligent Controllers, or approved equal.

5. Where installation allows, networked controller(s) and door interface modules may be combined in one or more control panels for space savings, each control panel housing networked controller(s) and door interface modules shall be provided with a power supply, charger, and battery backup system compatible with the ACAMS components as specified above.

6. Battery Backup: The battery backup package shall be compatible with the power supply and charger package included in the networked controller control panel and door interface module control panel enclosures. The battery backup shall include the following features:

   a. Rechargeable Sealed Lead Acid (SLA) type, using Absorbent Glass Matt (AGM) technology.

   b. Protective enclosure rated for the surrounding environment, NEMA rated based on area type as specified in Section 26 05 00.

   c. Built-in terminals for conductors to charger and load.

   d. Rated 12 volts with minimum capacity 20-hour rate of 7.2 Ah and 15-minute rate of 3.5 Ah.

   e. Operating temperature range during charge: -4°F to 122°F.

J. SIGNAL AND COMMUNICATION CABLE:

1. Copper signal and communication cables shall be as required by the ACAMS component manufacturer and as specified in Section 26 05 19.

2. Ethernet cables:

   a. Indoor: Category 6 (CAT6) shielded plenum/non-plenum terminated to CAT6 patch panel.

   b. Outdoor: CAT6 shielded waterproof and UV rated terminated to CAT6 patch panel.

K. SOFTWARE

1. Provide all necessary software packages and licenses required for a complete and functional system.

2.04 NAMEPLATES

A. In addition to the manufacturer's identification, ACAMS control panels shall be provided with phenolic nameplates showing the equipment tag number and description specified in subsection 1.01 of this Section. Nameplates shall be back engraved type and shall comply with Section 26 05 00.

2.05 SPARE PARTS

A. The following spare parts shall be provided:

1. One of each type of networked controller provided.

2. One of each type of door interface module provided.

3. One door card reader.

2.06 WIRE AND CABLE

A. Low voltage wire and cable shall be provided and installed as required per Division 26 requirements.

B. Wire and cable shall be selected, sized, and used as appropriate for the device application in accordance with the device manufacturer's specifications, voltage and load, and distance of the wire/cable run.

C. Wire and cable runs shall be "home run".

D. Mid-run splices shall not be permitted.

E. Provide surge arrestor kits as recommended by the manufacturer and as required by the NEC.

PART 3 EXECUTION

3.01 INSTALLATION

A. Coordinate with Sections 26, 27, and 28 (if a sub-Contractor to Division 28) Contractors and the Owner to provide and install and make fully operational all components required for a fully functional system.

B. All equipment locations shall be coordinated with other trades. Coordinate Work with other trades to verify exact routing of all cable and conduit before installation.

C. Provide easy, safe, and code-mandated clearances at equipment enclosures, and other equipment requiring maintenance and operation.

D. Install the equipment in accordance with the Contract Documents, all applicable codes and standards, and the Manufacturer's written instructions. The installed system shall meet all applicable equipment and performance requirements.

E. Installation, programming, and testing of ACAMS shall be performed by an authorized and factory-trained supplier.

F. Devices and equipment shall be installed in accordance with the requirements of the Construction Documents and the manufacturer's recommendations. Refer to contract drawings that represent facility and building plans and the Officer-in-Charge approved diagrams and materials. Electrical devices, wiring, conduits, etc. shall meet the various electrical area classification, Division 26 specification requirements, and the National Electrical Code Article 500 hazardous classification area requirements as shown in the Contract Drawings.

G. Only access control circuits shall be in access control conduits and raceways. Wiring splices shall not be permitted, except at device connections. Wiring shall be checked and tested to ensure that there are no grounds, opens, or shorts. Transposing or changing color coding on wiring is unacceptable.

3.02 TESTING

A. The following testing is in addition to Section 26 08 00 requirements.

B. Perform the following additional tests at a minimum:
   1. Visually inspect installation and correct cabling or connectors if the following conditions exist:
      a. Mechanically damaged cable
      b. Too small bending radii
      c. Disregard of minimum spacing
      d. Defective connectors
      e. Missing labels on cables
      f. Wiring pinouts do not meet terminated equipment requirements
   2. Copper transmission media cable:
      a. No short circuit between the wires
      b. No wire breaks
      c. No pair has been separated
      d. Cable length is less than 100 m
      e. Near-end and far-end cross talk
      f. Permissible attenuation values
   3. Performance testing shall be conducted to measure the following characteristics at a minimum: video transfer speed, storage and retrieval, and local refresh rate on Owner workstations.
   4. Performance testing shall include verifications of acceptable image clarity and ability to control camera zoom functions.
   5. Contractor shall coordinate testing of the video management system with the Owner's Representative, which will require Owner assistance to access the network. Contractor shall confirm that all cameras provided under this Section can be monitored over the network, both directly and via the video management system. Contractor shall also confirm that recorded data for all cameras hosted by the video management system and/or NVR can be accessed over the network from the laptop. The Owner's Representative shall retain the right to witness this testing and shall be provided with a minimum of five (5) days notice prior to the test.

3.03 MANUFACTURER'S SERVICE

A. Training:
   1. Provide a Manufacturer's representative or certified technician skilled in equipment use at the Site for the following activities. Specified durations do not include travel time to or from the Site.
      a. Provide minimum 6 hours training session for up to 6 Owner staff members that includes configuration, operation, troubleshooting, and warranty coverage for cameras provided under this Section.

B. MANUFACTURER SUPERVISION AND INSPECTION: The Contractor shall have the manufacturer of the ACAMS equipment provide the services of a qualified and factory-trained technical representative to supervise and instruct the Contractor in installation procedures. The representative shall supervise and inspect the ACAMS during installation and supervise the performance of testing and commissioning activities.

C. IN-PROGRESS INSPECTIONS:
   1. Inspection shall be performed at the conclusion of cable pulling, prior to closing of ceilings or walls. Inspect the method of cable routing, support and the fire-stop used at wall, floor, or ceiling penetrations.
   2. Inspection shall be performed at completion of Ethernet cable termination to validate cables are terminated in accordance with TIA/EIA specifications, with minimum bend radius adhered to, and verify that cable ends are dressed neatly and orderly.

D. FINAL INSPECTION: Final inspection of the ACAMS shall validate that the system cables were installed, and installation meets the NEC stated workmanship requirements.

3.04 PROGRAMMING

A. Request ACAMS parameter review by CCWTP a minimum of three weeks prior to the programming of the system parameters.

3.05 DOCUMENTATION

A. Update the ACAMS record as-built documentation to show additions and changes to the system during installation and to document the settings of installed equipment.

B. Provide information for all devices installed: device name, device type, IP address, serial number, MAC address, manufacturer, manufacturer's part number, description of part, warranty, expiration date of warranty, credential information (User ID, Password) and license keys as applicable. (Format: one (1) hard copy and Microsoft Excel electronic file).

3.06 SYSTEM TESTING

A. PRELIMINARY OPERATIONAL TESTING:
   1. Conduct operational tests of each equipment item or each equipment system for not less than 24 hours without interruption.
   2. Furnish personnel, power, and necessary facilities for conducting the test operations. System components shall operate satisfactorily, under continuous full load for the duration of the test period. If any part of a unit shows evidence of unsatisfactory or improper operation during the test period, correction or repairs shall be made and the full operational test, as specified above, shall be repeated after all parts operate satisfactorily.

B. FINAL OPERATIONAL TESTING:
   1. CCWTP will test the system for seven days by operating either under actual or simulated conditions before ACAMS final acceptance. Defects of material or workmanship that appear during this test period shall be corrected and the final test performed before final acceptance.

2. Completion of the installation; in-progress and final inspections; receipt of the test and record as-built documentation; and successful performance of the system for a two-week period, after the seven-day test, shall constitute acceptance of the system.

3.07 SYSTEM PERFORMANCE

A. CCWTP shall activate the ACAMS components to validate operation of the ACAMS.

B. Equipment manufacturer factory-trained representative shall provide a minimum of 16 man-hours on-site time for assisting the CCWTP with configuration of ACAMS components and software.

3.08 TRAINING

A. CONFIGURATION AND OPERATION: Equipment manufacturer factory-trained representative shall conduct configuration, monitoring, and operational training conforming to the requirements of Div. 01. A minimum of 8 man-hours on-site including training materials and expenses shall be provided for four CCWTP personnel.

END OF SECTION

SECTION 28 23 00

VIDEO MANAGEMENT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies requirements for the video management system which includes video cameras, network video recorders (NVRs), and video camera software. Video camera software shall be installed on new, dedicated or existing workstations, as required, by CCWTP. Section 26 05 19 specifies requirements for data communication cables and their installation. Division 27 Sections specify terminations and testing, respectively, for data communication cables

B. Cameras shall be located as specified on the Drawings. The NVR, video camera/security software, and servers associated with the CCWTP's video management system shall be new. Contractor shall confirm the new video management system vendor and version with CCWTP prior to beginning work.

C. Integration of new cameras into the video management system shall be provided by CCWTP's Subcontractor. The Contractor shall be responsible for providing the supporting infrastructure for the video system. CCWTP will rovide configuration of network switches, patching of fiber-optic and cables at network cabinets and racks, and host IP address assignments for the cameras. The Contractor shall request host IP address, subnet mask, and default gateway information from CCWTP via a Request for Information (RFI). The Contractor shall coordinate the integration, testing, and configuration work for the cameras with CCWTP to minimize outages and disruptions to plant processes.

1.02 QUALITY ASSURANCE

A. Reference Standards:
   1. Network
      a. IEEE
         1) 802.3 Ethernet Standards
         2) 802.1x – Port-based authentication
   2. Video
      a. ISO / IEC 14496 –10, MPEG-4 Part 10 (ITU H.264)
      b. ISO / IEC 10918 – JPEG
      c. ONVIF – Profile S and Profile G
   3. Emissions
      a. FCC-47 CFR Part 15, Class A
      b. CE, Class A
      c. ICES-003, Class A
   4. Environmental
      a. ANSI / IEC 60529 – Degrees of Protection Provided by Enclosures – IP66
      b. IK10 (20J) Impact Resistance / IEC62262

c. National Electrical Manufacturers Association, NEMA 250-2003, 4X Enclosure Definition

B. Unit Responsibility:
   1. The Contractor or security Subcontractor specified in this Section shall integrate all new video cameras into the video management system.

C. Contractor Requirements:
   1. CCWTP may provide a pre-qualified security Subcontractor to perform the work specified in this section without the need to provide Evidence of Experience.
   2. The Contractor or security Subcontractor shall be a licensed security contractor with a minimum of five (5) years experience installing and servicing systems of similar scope and complexity. The Contractor shall provide three (3) current references from clients with systems of similar scope and complexity which became operational in the past three (3) years. The technicians shall have a minimum of three (3) continuous years of technical experience in electronic security systems.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 26 05 00.

1.04 SUBMITTALS

A. General:
   1. Submittals and transmittal procedures for submittals are defined in Section 01 33 00. Submit in accordance with the procedures set forth in the General Conditions of the Contract Documents and Section 01 33 00 that include drawings, information and technical data for equipment and as required in Section 26 05 00.

B. Action Submittals:
   1. Package 1:
      a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
         1) Section 01 79 00 – Demonstration and Training
         2) Section 01 78 23 – Operating and Maintenance Data
         3) Section 26 05 00 – Common Work Results for Electrical
         4) A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
         5) The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

6) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

b. A copy of the contract document instrumentation network diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

c. A copy of the contract document electrical plan drawings, sections, and details showing sensor installation locations and details. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

d. Contractor or security sub-Contractor experience and resumes for the personnel installing the cameras and integrating them into the Owner's existing video management system. Include factory training certifications.

2. Package 2:

a. Marked product literature of all cameras, mounting hardware, cable junction boxes, and accessories to be provided.

b. Installation drawings for only the camera equipment and mounting accessories to be provided. Drawings shall include:

1) Floor plan drawing(s) and riser diagram(s) showing intended installation locations of cameras along with mounting hardware, brackets, poles/stanchions, base plates, cable junction boxes, and other necessary appurtenances for a complete installation.

2) Complete interconnection diagram(s) of all cameras with their associated junction boxes, including wiring, terminations, and details of interconnection to data transmission media and data communication network.

3) Details of surge protection device installation.

c. Coordination drawings:

1) Floor plans, elevations, and details indicating all floor, wall, and ceiling penetrations.

d. List of miscellaneous items, cables, spare parts, that will be provided.

C. Closeout Submittals:

1. Package 3:

a. Final reviewed submittal, including revised as-built submittal drawings.

b. Manufacturer's operation and maintenance information, edited for this project, as specified in Section 01 78 23.

PART 2 PRODUCTS

2.01 GENERAL

A. Video surveillance cameras and equipment shall comply with the following requirements:
   1. All cameras shall be IP camera technology and shall connect to shielded twisted pair (STP) patch panels in network cabinets and racks for final connection to the data communication system network switch by CCWTP, as indicated in the specifications and Drawings.
   2. All cameras shall be capable of being powered by Power over Ethernet (PoE) technology. PoE power for cameras shall originate from the data communication system network switch.
   3. All cameras shall use CAT6A, Class E_A cable for signal transport as specified in Section 26 05 19. Camera video signals and power shall be via the same cable. Cameras that require greater power than can be provided by the standard IEEE 802.3bt PoE provided by the data communication system network switch, shall be powered by centralized wall-mounted high power PoE power injectors or centralized wall mounted CCTV power supplies where possible.
   4. All video related equipment requiring building power shall be connected to building UPS circuits. The Contractor shall be responsible for coordinating the electrical load requirements of the equipment provided in this Section in the UPS load calculations submitted under Division 26.
   5. Cameras located outdoors shall be provided with surge protectors.
   6. All equipment shall be installed in accordance with this specification and the manufacturers recommendations. Provide and install any and all equipment necessary to provide a complete and operating system, and meet the full intent of this design and other specifications within these Contract Documents. Any equipment such as consumables, terminators, or any other materials or equipment needed to install this system shall be considered ancillary and be provided as a part of this project.

2.02 INDOOR CAMERA

A. Video
   1. Camera shall be capable of 2 simultaneous streams, each of which may have the following properties:
      a. Compression type:
         1) H.264 (high, main, or base profiles) available in stream 1 and stream 2
         2) MJPEG, available in stream 2
      b. Bit rate:
         1) 0.5 to 8 Mbps
      c. Frame rate:
         1) Variable from 1 to 60 frames per second
      d. Resolution:
         1) 2.01M (Full HD): 1920x1080
         2) 0.92M (HD): 1280x720
      e. 130 dB Wide Dynamic Range (WDR)

f. Zoom
    1) Digital: 12X
    2) Optical: 30X

2. Storage and Recording
    a. Camera shall have onboard SD card storage
        1) Card type: SDXC
        2) Capacity: up to 2 TB
    b. Local SD storage shall have the ability to be backed up to alternate media without removal of the SD card from the camera
    c. Local recording on the SD card shall commence upon loss of network connectivity, based on a pre-programmed schedule.
    d. Video shall be recorded continuously in the case of network outage.
    e. Alarm recording: Camera shall capture selectable 1, 5, or 10 second video clips on camera sabotage, motion detection, or alarm input.
    f. Video recording and storage shall support ONVIF profile G.
3. Camera Optics
    a. Sensor Type:
        1) 1/2.8 Sony Exmor CMOS
    b. Lens:
        1) 4.7 – 94 mm variable, F1.6 – F4.7 focal length, with remote auto-focus
        2) Horizontal angle of view:
            a) 63.7 degrees wide and 2.3 degrees tele
        3) Focus settings:
            a) Auto focus: Automatically focuses during operation.
            b) Sure focus: Camera auto focuses when pan, tilt, and zoom operations are complete or if the IR cut filter changes state.
            c) Focus trace: Enables camera to use a focus trace curve when zooming based on the distance to ground-level targets in the scene.
    c. Day and night settings
        1) Minimum illumination
            a) Color mode: 0.20 lux (33 ms, F1.6), 0.025 lux (250 ms, F1.6)
            b) Color mode (low light): 0.03 lux (33 ms, F1.6), 0.008 lux (250 ms, F1.6)
            c) Black & white mode: 0.06 lux (33 ms, F1.6), 0.008 lux (250 ms, F1.6)
            d) Black & White mode (low light): 0.004 lux (33 ms, F1.6), 0.001 lux (250 ms, F1.6)

B. Camera Movement
1. Variable speed: 0.1 to 80 degrees per second
2. Preset accuracy: ±0.1 degrees
3. Pan movement: 360 degrees continuous pan rotation
4. Vertical tilt: +1 to -90 degrees
5. Maximum pan speed: Up to 450 degrees per second
6. Maximum tilt speed: Up to 450 degrees per second

7. Manual Pan/Tilt Speeds
    a. Pan: 0.1 to 80 degrees per second manual operation
    b. Tilt: 0.1 to 45 degrees per second manual operation
8. Preset Speeds
    a. Pan: 450 degrees per second
    b. Tilt: 450 degrees per second

C. Network
1. Ethernet: 100 BASE-TX with RJ-45 connector
2. Supported protocols:
    a. Transmission Control Protocol (TCP), Internet Protocol (IP) v4 and v6, User Datagram Protocol (UDP)
    b. Configuration: Dynamic Host Configuration Protocol (DHCP)
    c. Web services: Hypertext Transfer Protocol (HTTP), Secure HTTP (HTTPS)
    d. Network services: Domain Name System (DNS), Network Time Protocol (NTP), Internet Control Message Protocol (ICMP), Simple Network Management Protocol (SNMP) v2c/v3, Universal Plug and Play (UPnP)
    e. Media: Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP)
    f. Multicast: Internet Group Management Protocol (IGMP)
    g. Notifications: File Transfer Protocol (FTP), Simple Mail Transfer Protocol (SMTP)
    h. Remote Access: Secure Shell (SSH)
    i. Security: Secure Sockets Layer (SSL), IEEE 802.1x (EAP-MD5, EAP-TLS, EAP-TTLS, EAP-PEAP and EAP-FAST)
    j. Quality of Service: IEEE 802.1p Layer 3 Differentiated Services Code Point (DSCP)
3. Security
    a. Camera shall support IP address filtering whereby users can enter a list of allowed or blocked IP addresses for viewing video and configuring camera settings
    b. Camera shall provide three levels of user access with password protection.
    c. User authentication shall be available through a Lightweight Directory Access Protocol (LDAP) server.

D. Mechanical and Environmental
1. Housing material
    a. Back Box: Aluminum
    b. Dome Drive: Aluminum, thermo plastic
    c. Lower Dome: Nylon
    d. Dome: Clear
2. Conduit attachments
    a. Pendant mounted: 1.5 inch NPT
    b. In-ceiling: 3/4 inch NPT

3. Temperature
    a. Non-environmental
        1) In-Ceiling: 32 to 122 degrees F
        2) Pendant: 23 t 122 degrees F
    b. Environmental
        1) In-Ceiling and Pendant: -4 to 140 degrees F
4. Operating Humidity
    a. Non-environmental:
        1) 10 to 90 percent, RH noncondensing
    b. Environmental:
        1) 10 to 100 percent, RH condensing

E. Electrical
1. Input Power:
    a. PoE (802.3at)
        1) 18W consumption, Environmental models (with heater off, blower on)
        2) 15W consumption, Non-Environmental models (with heater and blower off)
    b. PoE (802.3bt)
        1) 60W consumption, Environmental models (with heater and blower on)
        2) 15W consumption, Non-Environmental (with heater and blower off)
2. Ports: Ethernet RJ-45 connector

F. Software
1. Camera Software
    a. Camera shall have built in web server which supports browser-based configuration
    b. Camera web server shall allow access to camera information and all primary software functions
    c. Camera shall offer video viewer and configuration
2. Camera Analytics
    a. Analytics shall be pre-loaded in the camera.
    b. Camera shall have the ability to detect motion within user defined areas of the video image.
    c. Number of simultaneous running analytic behaviors: 3
    d. Configurable behaviors:
        1) Abandoned Object - Detection of objects placed in a defined zone and triggers an alarm if the object remains in the zone longer than the user-defined time allows.
        2) Adaptive Motion - Detection and tracking of objects that enter a scene and triggering of an alarm when the objects enter a user-defined zone
        3) Auto Tracker - Detection and tracking of movement in the camera's field of view, with automatic pan and tilt to follow the moving object until the object stops or disappears from the monitored area

4) Camera Sabotage - Detection of contrast changes in the field of view, suitable to detect lens obstruction or unauthorized repositioning of the camera
5) Directional Motion - Detection of person or object moving in a specified direction
6) Loitering Detection – Identification of people or vehicles remaining in a defined zone longer than a user-defined time
7) Object Counting - Counting the number of objects that enter a defined zone or cross a tripwire
8) Object Removal – Detection of object is removed from a defined zone
9) Stopped Vehicle – Detection of vehicles stopped near a sensitive area longer than a user-defined time

G. Certifications and Ratings
1. CE, Class A
2. FCC, Class A
3. UL listed
4. NEMA Type 4X

H. Manufacturer:
1. Pelco Spectra Enhanced Series IP PTZ Dome, Model S6230-EGL1.
2. Or approved equal.

2.03 OUTDOOR CAMERA

A. Video
1. Camera shall be capable of 2 simultaneous streams, each of which may have the following properties:
a. Compression type:
1) H.264 (high, main, or base profiles) available in stream 1 and stream 2
2) MJPEG, available in stream 2
b. Bit rate:
1) 0.5 to 8 Mbps
c. Frame rate:
1) Variable from 1 to 60 frames per second
d. Resolution:
1) 2.01M (Full HD): 1920x1080
2) 0.92M (HD): 1280x720
e. 130 dB Wide Dynamic Range (WDR)
f. Zoom:
1) Digital: 12X
2) Optical: 30X

2. Storage and Recording
    a. Camera shall have onboard SD card storage:
        1) Card type: SDXC
        2) Capacity: up to 2 TB
    b. Local SD storage shall have the ability to be backed up to alternate media without removal of the SD card from the camera
    c. Local recording on the SD card shall commence upon loss of network connectivity, based on a pre-programmed schedule.
    d. Video shall be recorded continuously in the case of network outage.
    e. Alarm recording: Camera shall capture selectable 1, 5, or 10 second video clips on camera sabotage, motion detection, or alarm input.
    f. Video recording and storage shall support ONVIF profile G.
3. Camera Optics
    a. Sensor Type:
        1) 1/2.8 Sony Exmor CMOS
    b. Lens:
        1) 4.7 – 94 mm variable, F1.6 – F4.7 focal length, with remote auto-focus
        2) Horizontal angle of view
            a) 63.7 degrees wide and 2.3 degrees tele
        3) Focus settings
            a) Auto focus: Automatically focuses during operation.
            b) Sure focus: Camera auto focuses when pan, tilt, and zoom operations are complete or if the IR cut filter changes state.
            c) Focus trace: Enables camera to use a focus trace curve when zooming based on the distance to ground-level targets in the scene.
    c. Day and night settings:
        1) Minimum illumination
            a) Color mode: 0.03 lux (33 ms, F1.6), 0.008 lux (250 ms, F1.6)
            b) Black & white mode: 0.004 lux (33 ms, F1.6), 0.001 lux (250 ms, F1.6)

B. Camera Movement
1. Variable speed: 0.1 to 140 degrees per second
2. Preset accuracy: ±0.1 degrees
3. Pan movement: 360 degrees continuous pan rotation
4. Vertical tilt: unobstructed +40 to -90 degrees
5. Manual Pan/Tilt Speeds
    a. Pan: 0.1 to 80 degrees per second
    b. Tilt: 0.1 to 40 degrees per second
6. Preset Speeds: 140 degrees per second, both pan and tilt

C. Network
   1. Ethernet: 100 BASE-TX with RJ-45 connector
   2. Supported protocols:
      a. Transmission Control Protocol (TCP), Internet Protocol (IP) v4 and v6, User Datagram Protocol (UDP)
      b. Configuration: Dynamic Host Configuration Protocol (DHCP)
      c. Web services: Hypertext Transfer Protocol (HTTP), Secure HTTP (HTTPS)
      d. Network services: Domain Name System (DNS), Network Time Protocol (NTP), Internet Control Message Protocol (ICMP), Simple Network Management Protocol (SNMP) v2c/v3, Universal Plug and Play (UPnP)
      e. Media: Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP)
      f. Multicast: Internet Group Management Protocol (IGMP)
      g. Notifications: File Transfer Protocol (FTP), Simple Mail Transfer Protocol (SMTP)
      h. Remote Access: Secure Shell (SSH)
      i. Security: Secure Sockets Layer (SSL), IEEE 802.1x (EAP-MD5, EAP-TLS, EAP-TTLS, EAP-PEAP and EAP-FAST)
      j. Quality of Service: IEEE 802.1p Layer 3 Differentiated Services Code Point (DSCP)
      k. NTCIP 1205
   3. Security
      a. Camera shall support IP address filtering whereby users can enter a list of allowed or blocked IP addresses for viewing video and configuring camera settings
      b. Camera shall provide three levels of user access with password protection.
      c. User authentication shall be available through a Lightweight Directory Access Protocol (LDAP) server.

D. Mechanical and Environmental
   1. Housing material :
      a. Die-cast, extruded and sheet aluminum; stainless steel hardware.
      b. Pressurized integrated optics cartridge.
   2. Finish:
      a. Gray polyester powder coat
   3. Temperature
      a. -50 to 140 degrees F
   4. Operating Humidity
      a. Standard with pressurized integrated optics cartridge (IOC): 10 to 100% RH condensing
   5. Camera shall be provided with integrated window wiper with configurable delay and shut-off.

E. Electrical
   1. Input Power:
      a. PoE (802.3bt)
         1) 72W consumption, with heaters

2. Connectors:
    a. Ethernet: RJ-45 connector, 2 SFPs
    b. Aux: 20-pin terminal block

F. Software
    1. Camera Software
        a. Camera shall have built in web server which supports browser-based configuration
        b. Camera web server shall allow access to camera information and all primary software functions

            Camera shall offer video viewer and configuration
    2. Camera Analytics
        a. Analytics shall be pre-loaded in the camera.
        b. Camera shall have the ability to detect motion within user defined areas of the video image.
        c. Number of simultaneous running analytic behaviors: 3
        d. Configurable behaviors:
            1) Abandoned Object - Detection of objects placed in a defined zone and triggers an alarm if the object remains in the zone longer than the user-defined time allows.
            2) Adaptive Motion - Detection and tracking of objects that enter a scene and triggering of an alarm when the objects enter a user-defined zone
            3) Auto Tracker - Detection and tracking of movement in the camera's field of view, with automatic pan and tilt to follow the moving object until the object stops or disappears from the monitored area
            4) Camera Sabotage - Detection of contrast changes in the field of view, suitable to detect lens obstruction or unauthorized repositioning of the camera
            5) Directional Motion - Detection of person or object moving in a specified direction
            6) Loitering Detection – Identification of people or vehicles remaining in a defined zone longer than a user-defined time
            7) Object Counting - Counting the number of objects that enter a defined zone or cross a tripwire
            8) Object Removal – Detection of object is removed from a defined zone
            9) Stopped Vehicle – Detection of vehicles stopped near a sensitive area longer than a user-defined time

G. Certifications and Ratings
    1. CE, Class A
    2. FCC, Class A
    3. UL listed
    4. NEMA Type 4X

H. Manufacturer:
   1. Pelco Esprit Enhanced Series IP Positioning System, Model ES6230-12P.
   2. Or approved equal.

2.04 WIRE AND CABLE

A. Low voltage wire and cable shall be provided and installed as required per Division 26 requirements.

B. Wire and cable shall be selected, sized, and used as appropriate for the device application in accordance with the device manufacturer's specifications, voltage and load, and distance of the wire/cable run.

C. Wire and cable runs shall be "home run".

D. Mid-run splices shall not be permitted.

E. Provide surge arrestor kits as recommended by the camera manufacturer and as required by the NEC.

2.05 MOUNTING HARDWARE AND CABLE JUNCTION BOX

A. Wherever possible use mounting hardware from the camera manufacturer. Mount cameras at locations shown on Drawings.

B. Where manufacturer cable is provided, provide a cable junction box or water-proof connector with each outdoor camera to transition from manufacturer provided cable to Division 26 cable within an enclosure rated for the installation environment, as specified in Section 26 05 00.

2.06 SPARE PARTS

A. Provide the following spare parts for the project:
   1. One spare indoor camera.
   2. One spare outdoor camera.
   3. One spare PoE power injector of each type provided, if required.
   4. Package of 10 window wiper replacement blades (if used).
   5. One spare surge arrestor of each type provided.

PART 3 EXECUTION

3.01 INSTALLATION

A. Coordinate with Sections 26, 27, and 28 (if a Subcontractor to Division 28) Contractors and the Owner to provide and install and make fully operational all components required for a fully functional system.

B. All equipment locations shall be coordinated with other trades. Coordinate Work with other trades to verify exact routing of all cable and conduit before installation.

C. Provide easy, safe, and code-mandated clearances at equipment enclosures, and other equipment requiring maintenance and operation.

D. Install the equipment in accordance with the Contract Documents, all applicable codes and standards, and the Manufacturer's written instructions. The installed system shall meet all applicable equipment and performance requirements.

3.02 TESTING

A. The following testing is in addition to Section 26 08 00 requirements.

B. Perform the following additional tests at a minimum:
   1. Visually inspect installation and correct cabling or connectors if the following conditions exist:
      a. Mechanically damaged cable
      b. Too small bending radii
      c. Disregard of minimum spacing
      d. Defective connectors
      e. Missing labels on cables
      f. Wiring pinouts do not meet terminated equipment requirements
   2. Copper transmission media cable:
      a. No short circuit between the wires
      b. No wire breaks
      c. No pair has been separated
      d. Cable length is less than 100 m
      e. Near-end and far-end cross talk
      f. Permissible attenuation values
   3. Performance testing shall be conducted to measure the following characteristics at a minimum: video transfer speed, storage and retrieval, and local refresh rate on Owner workstations.
   4. Performance testing shall include verifications of acceptable image clarity and ability to control camera zoom functions.
   5. Contractor shall coordinate testing of the video management system with CCWTP's Representative, which will require CCWTP assistance to access the network. Contractor shall confirm that all cameras provided under this Section can be monitored over the network, both directly and via the video management system. Contractor shall also confirm that recorded data for all cameras hosted by the video management system and/or NVR can be accessed over the network from the laptop. CCWTP's Representative shall retain the right to witness this testing and shall be provided with a minimum of five (5) days notice prior to the test.

3.03 MANUFACTURER'S SERVICE

A. Training:

1. Provide a Manufacturer's representative or certified technician skilled in equipment use at the Site for the following activities. Specified durations do not include travel time to or from the Site.
    a. Provide minimum 6 hours training session for up to 6 Owner staff members that includes configuration, operation, troubleshooting, and warranty coverage for cameras provided under this Section.

END OF SECTION

SECTION 28 46 00

FIRE DETECTION AND ALARM - ADDESSABLE

PART 1 GENERAL

1.01 SUMMARY

A. Design, obtain all required permits for, furnish, install, test, and commission new addressable fire detection and alarm system(s) for the following structure(s):
   1. [Structure #1]

B. [Design, furnish, install, test, and commission a central fire alarm system monitoring panel to allow the Owner to monitor the activity of each individual structure's fire alarm panel from a central location. The central fire alarm monitoring panel shall be located at the [Admin Building].

C. Equipment List:
   1. Equipment numbers are as follows:

Item	Equipment No.	Location
Fire Alarm Control Panel	[FACP-####]	[Location]
Fire Alarm Control Panel	[FACP-####]	[Location]
Fire Alarm Control Panel	[FACP-####]	[Location]

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 26 05 33 – Raceways and Boxes for Electrical Systems
   2. [Section 21 10 00 – Water-Based Fire Suppression Systems]

1.03 REFERENCES

Reference	Title
[IFC][CFC][XXX]	[International Fire Code] [California Fire Code][Specific State Fire Code]
NECA 305	Standard for Fire Alarm Systems Job Practices
NFPA 72	National Fire Alarm and Signaling Code
NFPA 70	National Electrical Code
NFPA 101	Life Safety Code
NFPA 820	Fire Protection in Wastewater Treatment and Collection Facilities
UL 38	Manual Signaling Boxes for Fire Alarm Systems
UL 268	Smoke Detectors for Fire Alarm Systems
UL 268A	Smoke Detectors for Duct Application
UL 346	Waterflow Indicators for Fire Protective Signaling Systems
UL 464	Safety Audible Signaling Appliances
UL 521	Heat Detectors for Fire Protective Signaling Systems
UL 864	Control Units for Fire Protective Signaling Systems
UL 1424	Cables for Power-Limited Fire Alarm Circuits

Reference	Title
UL 1638	Visible Signaling Device for Fire Alarm and Signaling Systems

1.04 SUBMITTALS

A. Per Section 01 33 00

B. Product Data:
   1. Cutsheets for the following system components:
      a. Fire alarm control panels
      b. Manual pull stations
      c. Smoke detectors
      d. Duct smoke detectors
      e. Heat detectors
      f. Water flow indicating switches
      g. Valve tamper switches
      h. Audible notification appliances
      i. Visible notification appliances
      j. Fire alarm cable

C. Shop Drawings:
   1. System input/output matrix
   2. System riser diagram
      a. Show cable and raceway requirements.
      b. Show device addresses.
   3. Plan drawings
      a. Show visual notification appliance candela ratings.
   4. Installation and Mounting Details
   5. Calculations:
      a. Battery Sizing
      b. Voltage Drop

D. Operations and Maintenance (O&M) Manuals:
   1. Per Section 01 78 23.

1.05 QUALITY ASSURANCE

A. Regulatory Approvals:
   1. All system components shall be listed or approved by the following agencies:
      a. Underwriters Laboratories (UL)
      b. Factory Mutual (FM)

B. Certification and verification approval that the proposed equipment is acceptable to the local fire department and its component parts are as listed and are approved by the Fire Marshall.

1.06 DELIVERY, STORAGE AND HANDLING

A. Per Section 01 66 00

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section:
   1. Edwards
   2. Fike
   3. Honeywell
   4. Siemens

2.02 PERFORMANCE/DESIGN CRITERIA

A. Signaling Line Circuits (SLC):
   1. Class: B

B. Notification Appliance Circuits (NAC):
   1. Class: B

C. Communications to Central Station:
   1. Primary: [IP Network][Analog Telephone Line]
   2. Backup: [Cellular Modem]

D. Input/Output Matrix:
   1. Develop an input/output matrix as required to comply with the requirements of the authority having jurisdiction (AHJ), providing the following basic functionality as a minimum:

Input/Output Matrix

	Activate Notification	Indicate Alarm at FACP	Indicate Trouble at [illegible]	Indicate Supervisory at	Send Alarm Signal to	Send Trouble Signal to	Send Supervisory	Send Alarm Signal to	Send Trouble Signal to	Send Supervisory	Shut Down Associated						
Manual Pull Station	X	X			X			X									
Smoke Detector	X	X			X			X									
Duct Smoke Detector	X	X			X			X			X						
Water Flow Switch	X	X			X			X									
Valve Tamper Switch	X			X			X			X							
SLC Wiring Problem			X			X			X								
NAC Wiring Problem			X			X			X								

2.03 COMPONENTS

A. Fire Alarm Control Panel (FACP):
   1. Standard: UL 864 compliant
   2. Type: Addressable
   3. Power Supply: 120VAC with minimum 24 hour battery backup.
   4. Interfaces:
      a. Relay output contacts for remote monitoring of the following signals by SCADA/DCS:
         1) Alarm activated
         2) Supervisory Condition
         3) Trouble Condition
      b. [Modbus TCP Network Communication Port]

B. Manual Pull Stations:
   1. Standard: UL 38 compliant
   2. Action: Double
   3. Color: Red

C. Smoke Detectors:
   1. Standard: UL 268 compliant
   2. Type: Photoelectric

D. Duct Smoke Detectors:
   1. Standard: UL 268A compliant
   2. Type: Photoelectric
   3. Interfaces:
      a. Relay contact output for hard-wired shutdown of associated air handling equipment.
      b. Addressable port for interface to FACP.

E. Heat Detectors:
   1. Standard: UL 521 compliant

F. Water Flow Indicating Switch:
   1. Standard: UL 346 compliant
   2. Enclosure: NEMA 4

G. Valve Tamper Switch
   1. Standard: UL compliant.
   2. Enclosure: NEMA 4

H. Audible Notification Appliances:
   1. Standard: UL 464 compliant
   2. Type: Horn

3. Housing Color: Red

I. Visible Notification Appliances:
   1. Standard: UL 1638 compliant
   2. Type: Strobe
   3. Housing Color: Red

J. Fire Alarm Cable
   1. Standards:
      a. UL 1424 compliant
      b. NEC Type FPLP
   2. Jacket Color: Red

PART 3 EXECUTION

3.01 INSTALLATION

A. Perform all work in accordance with NECA 305 - Standard for Fire Alarm Systems Job Practices.

B. Install all fire alarm wiring in conduit in accordance with Section 26 05 33 – Raceways and Boxes for Electrical Systems. The use of plenum or riser rated cable outside of conduit is not acceptable.

3.02 FIELD QUALITY CONTROL

A. Provide the services of a NICET Certified Fire Alarm Technology Technician (level 2 or higher) to perform system startup.

3.03 SYSTEM START UP

A. System Testing:
   1. Perform in accordance with NFPA 72 - National Fire Alarm and Signaling Code.
   2. Address any deficiencies identified during system testing, including any requirements of the authority having jurisdiction (AHJ), and re-test all modified portions of the system.
   3. Submit final certified test reports to the Owner.

END OF SECTION

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SECTION 31 09 00

GEOTECHNICAL INSTRUMENTATION AND MONITORING

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section specifies the requirements for providing, installing, and monitoring of ground movements around excavations and shoring work, as well as movements of existing improvements, utilities, and roadways, before, during and after excavation and shoring operations.

B. Work shall be performed by a State of Utah Professional Licensed Surveyor, by such methods, instruments, tools, and other materials necessary to perform the Work to the required accuracies.

C. Conduct preconstruction surveys to depict existing interior and exterior conditions of buildings, utilities, underground structures and structural improvements, streets, sidewalks, and the like, within the area of influence of the work site. Monitor these conditions as construction progresses and continue records of damage or influence if necessary.

1. Existing buildings, utilities, and other related structural improvements and properties located in the area of influence of the work site are subject to possible damage as a result of heavy construction activities, including but not limited to excavation.
2. Survey and identify conditions existing in and around the properties anticipated to be potentially affected by the construction operations.

1.02 REQUIREMENTS

A. Minimum instrumentation and monitoring requirements are presented herein. Conduct additional instrumentation and monitoring as necessary to comply with the Approved Integrated Excavation Plan and to control the work and ensure the safety of the work.

B. The CONTRACTOR shall obtain applicable encroachment permits and traffic control permits to perform the work.

C. Remove or abandon in place all instrumentation in accordance with applicable laws, regulations and guidelines and restore the ground at the completion of the project. As a minimum, instrumentation shall be demolished within five feet of the ground surface.

1.03 DEFINITIONS

A. SETTLEMENT MONITORING POINTS (SMP) – Each Settlement Monitoring Point shall be attached to the structure being monitored.

B. VIBRATION MONITORING POINTS (VMP) – Locations where a seismograph will be set up. VMP should be located a minimum of four (4) feet from existing structures to reduce reflected vibrations.

C. INCLINOMETER – Sealed casing installed outside of the excavation to monitor horizontal displacement related to the excavation or failure of the excavation.

D. CRACK MONITORS. Avongard Tell tale or approved equal.

1.04 REFERENCES

A. This Section includes references to the standards as specified in the Contract Documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements affording the greatest protection to the OWNER shall apply, as determined by the CONSTRUCTION MANAGER.

1.05 SUBMITTALS

A. Submittals in accordance with the General Conditions and Section 01 33 00.

B. Permits. List permits, third party approvals, and approval contract submittals required to perform the work.

C. Submit proposed Preconstruction Survey Plan for Engineer's review.

D. Submit product data on manufactured survey markers for SMP.

E. Submit product data on vibration monitors, inclinometer casing, and inclinometer probes to be used including accuracies. Include calibration dates of vibration monitors and inclinometer probes.

F. Description of methods and materials for installing and protecting the instruments.

G. Proposed location of inclinometer casings with respect to proposed excavation in general accordance with the plans.

H. Materials and mixture proportions for cement-bentonite grout for installing and backfilling inclinometer casings.

I. For all instrumentation installed in borings, submit proposed schedule for installing instruments, detailed step by step procedures for installation, including post installation acceptance test, together with a sample installation record sheet. The installation procedures shall include:
   1. Specifications for proposed grout mixtures, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size and quantity.
   2. Drill casing or auger type and size.
   3. Method for overcoming buoyancy of instrumentation components during grouting.
   4. Method of sealing joints in pipes and casing to prevent ingress of grout.

J. Prior to commencement of activities submit the following:
   1. Submit a copy of the monitoring report form for approval. The results shall be presented in a graphical format showing successive readings and total cumulative vertical movement (i.e., settlement or heave), total cumulative horizontal movement, maximum vibration, and total cumulative rotation per day.
   2. Submit initial readings.

3. Submit a schedule and outline of procedures and timing for the performance of monitoring.
4. Submit final readings

K. Read inclinometers a minimum of 3 times per week during excavation, once per week for one month after excavation is complete, and once per month until backfill is complete.

L. During activity, submit a daily monitoring report to the CONSTRUCTION MANAGER on the approved form. Submit SMP, vibration monitor, and inclinometer reports to the CONSTRUCTION MANAGER within 12 hours after the readings are taken. If readings exceed Action Trigger Levels, immediately notify CONSTRUCTION MANAGER and submit monitoring data within 2 hours after readings are taken.

M. Submit a mitigation plan and actions to be taken if SMP, vibration monitor, or inclinometer readings exceeds Action Trigger Levels.

Stop the Work and implement the mitigation plan in the event that SMP, vibration monitor, or inclinometer Maximum Allowable Reading are exceeded.

N. Submit close-out report on the approved form.

1.06 QUALITY ASSURANCE

A. A Professional Land Surveyor registered in the State of Utah shall supervise and direct all survey activities related to monitoring and the establishment of horizontal and vertical control.

B. Survey for location and elevation shall be performed by individuals with a minimum of 3 years surveying experience performing the type of survey required.

C. Surveys are to be performed to a minimum horizontal accuracy of 0.02 feet (1/4 inch) and minimum vertical accuracy of 0.01 foot (1/8 inch).

D. Seismographs shall have a recording accuracy as outlined in Specification 31 41 01 Vibration Control.

E. The inclinometer equipment shall be capable of providing a system accuracy of ±0.01 inch per reading.

PART 2 EQUIPMENT, PRODUCTS, AND MATERIALS

2.01 PRODUCTS

A. NOT USED

2.02 MONITORING REPORTS

A. Monitoring shall be provided on an approved report form. The report form will clearly indicate the following information:
1. SMP, VMP, and inclinometer identification number and marker type, and calibration date.

2. Station and offset along the pipe alignment.
3. Initial elevation and horizontal coordinates.
4. Elevation and horizontal coordinates from subsequent readings.
5. Direction of movement.
6. Date and time of readings.
7. Names of the individuals who performed the monitoring.
8. Bench mark and horizontal control point data including identification, location, elevation and horizontal coordinates.
9. Inclinometer readings shall be shown graphically with a maximum horizontal axis of 1 inch. Each report shall include a cumulative displacement plot for the A and B axis.
10. Inclinometer reports shall include the maximum displacement of the casing reported to 0.01 inch (not inclusive of readings above or near the ground surface).

B. The approved report for shall be used for initial, all daily and close-out submittals.

2.03 INSTRUMENT SCHEDULE

A. Provide SMP, VMP, and inclinometers as shown on the drawings.

PART 3 EXECUTION

3.01 QUALITY CONTROL

A. Instrument Installation. Install all instruments within 3 ft of the horizontal location shown on the Contract Drawings or as approved or directed by the ENGINEER.

B. Should actual field conditions prevent installation of instruments at the location and elevations shown on the Contract Drawings or specified herein, obtain prior acceptance from the ENGINEER for new instrument location and elevation.

3.02 SAFETY REQUIREMENTS

A. Methods of installing the instrumentation shall be such as to ensure the safety of the work, project participants, the public, third parties, and adjacent property, whether public or private.

3.03 INSTALLATION

A. Begin immediately upon Notice to Proceed and submit applicable portions of this survey report and data to the Engineer for compliance review prior to the start of construction activities.

B. Survey all structures within the construction area. Submit any Contractor recommended deviations from this area, if any.

C. Install six (6) crack monitors, at the approximate locations of the SMP and as directed by the ENGINEER, permanently affixed to structure.

D. SMP, Inclinometers, and VMP shall be located as shown on the Contract Drawings.

E. Each inclinometer shall be outside the excavation. Inclinometer locations should be in an appropriate location shown in the IEP to detect a potential failure and in a location approved by the ENGINEER.

F. Inclinometers shall be installed to a tip depth a minimum of 30 feet below the deepest excavation or 15 feet deeper than proposed shoring, whichever is deeper.

3.04 INSTALLATION AND INITIAL READINGS

A. A minimum of fourteen (14) days prior to activity, install all SMP, crack monitors, and inclinometer casings unless otherwise approved by the Engineer. Survey the SMP for the horizontal and vertical location. Submit the results to the CONSTRUCTION MANAGER.

B. A minimum of seven (7) days prior to activity, survey the location of each SMP. Submit the results to the CONSTRUCTION MANAGER.

C. A minimum of one (1) days prior to activity, survey the location of each SMP. Submit the readings to the CONSTRUCTION MANAGER.

D. A minimum of seven (7) days prior to activity, and at least 24 hours after casing installation obtain baseline readings for the inclinometer casing. Take two (2) or more baseline readings and establish the best possible baseline reading. Submit report with graphical representation of checksums of chosen baseline reading to the CONSTRUCTION MANAGER.

3.05 MONITORING

A. Monitor all SMP, VMP, crack monitors, and inclinometers to the accuracy and the frequency specified. Frequency:

1. As a minimum, the CONTRACTOR shall follow the following schedule:

Table 1: Frequency

Instrument Type	During Dewatering	During Installation/Removal of the Shoring	During Excavation	During Construction	Post Construction – 3 months after end of construction
SMP	Once (1) per day	Once (1) per day	Once (1) per day	Once (1) per day	Weekly
VMP	NA	Continuously	NA	Once (1) per day during backfill compaction	NA
Inclinometer*	NA	NA	Three (3x) per week	Once (1) per week after excavation	NA
Crack monitor	Once (1) per day	Once (1) per day	Once (1) per day	Once (1) per week after excavation	NA

**see section 1.05 J*

2. The CONTRACTOR shall perform additional monitoring as necessary to control construction and to ensure the safety of the work.

B. Notify CONSTRUCTION MANAGER within 2 hours of taking readings if action limits are exceeded. The action and maximum limits for ground distortions are provided in Table 2.

SECTION 31 10 00

SITE CLEARING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This section specifies site preparation which consists of clearing, grubbing and demolition.

B. Existing Conditions: The Contractor shall determine the actual condition of the site as it affects this portion of work. The Contractor shall locate and preserve utilities that are to remain in service.

C. Protection: Site preparation shall not damage structures, landscaping or vegetation adjacent to the site. The Contractor shall repair, or replace any damaged property. Contractor is responsible for developoing and managing a Storm Water Pollution Pervention Plan with detail Erosion and Sediment Control Plans.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 CLEARING AND GRUBBING

A. Unless otherwise specified, the Contractor shall remove obstructions such as brush, trees, logs, stumps, roots, heavy sod, vegetation, rock, stones larger than 6 inches in any dimension, broken or old concrete and pavement, debris, and structures where the completion of the work require their removal.

B. Material that is removed and is not to be incorporated in the work shall be disposed of off the site.

C. Contractor Stagging and Laydown Areas – provide surface stabilization after clearing and grubbing.

3.02 DEMOLITION AND REMOVAL

A. Structures: Demolition and removal of structures consist of removal of abandoned superstructures, foundation walls, footings, slabs and any other structures. Excavations caused by existing foundations shall be cleared of waste, debris and loose soil, and refilled as specified.

B. Pavement: When portions of asphalt pavements and concrete pads are to be removed and later construction is to be connected, edges shall be saw cut, on a neat line at right angles to the curb face.

3.03 UTILITY INTERFERENCE

A. Where existing utilities interfere with the prosecution of the work, the Contractor shall relocate them in accordance with the General Conditions of the Contract Documents.

B. Before starting, the Contractor shall arrange for disconnection of all utility services that are to be removed or which interfere with Work with the Owner and the respective utility company.

END OF SECTION

SECTION 31 21 33

TRENCHING, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Section specifies excavation, trenching, backfilling and compaction for underground utilities and appurtenances.

B. The CONTRACTOR shall provide all labor, materials, equipment, supervision, and testing necessary to construct the improvements.

C. Excavating, trenching, bedding and backfill shall be performed as specified herein and in accordance with the requirements of the Agency with jurisdiction over the rights-of-way in which the Work is performed. In the case of conflict between the Agency's requirements and these specifications, the requirements affording the greatest protection to the OWNER shall apply, as determined by the CONSTRUCTION MANAGER.

D. Work must be performed in accordance with OSHA and all local, state and federal requirements.

E. Stockpile excavated trench materials offsite, not in roadway.

1.02 REFERENCES

A. Referenced Standards: This Section incorporates by reference the latest revision of the following documents. These references are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

1. ASTM International (ASTM):
    a. C33, Standard Specification for Concrete Aggregates.
    b. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).
    c. D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
    d. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
    e. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
    f. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Method (Shallow Method).

1.03 QUALIFICATIONS:

A. Hire an independent certified soils laboratory to conduct source materials testing and compaction testing.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00 Submittal Procedures.

B. Product technical data per Section 31 23 00, Excavation and Fill.

C. Contractor's Safety Plan for personnel.

D. Contractor-obtained permits.

E. Qualifications: Name(s) and qualifications of trenching and excavation Competent Person(s). To qualify as a Competent Person, he or she shall have completed the equivalent of 10-hour Utah OSHA (UOSH) Construction Safety Training within the last five (5) years.

F. The following information shall be provided prior to beginning Work:
   1. Excavation sheeting, shoring, and bracing system design in accordance with Section 31 41 00.
   2. Qualification information of excavation support system designer (Professional Engineer registered in the State of Utah) in accordance with Section 31 41 00.

G. Submit report from a testing laboratory verifying that material conforms to the specified gradations or characteristics for pipe zone and trench backfill material including sand, rock for foundation stabilization, and water. Include laboratory moisture-density relations of soils in accordance with ASTM D1557.

H. Submit method of compaction in pipe zone including removal sequence of shoring where used.

I. Submit mix designs for controlled low strength material (CLSM, aka flowable fill). Comply with CLSM cold weather placement as specified herein.

J. Submit excavation plans for worker protection and dewatering plans in accordance with Section 31 23 19.

1.05 SITE CONDITIONS

A. Plan for and provide work zone traffic control where required to meet Salt Lake City agency requirements.

B. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving.

C. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property owners.

D. Provide full access to public and private premises to prevent interruption of travel.

E. Protect and maintain benchmarks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of the Owner and controlling agency.

F. Verify location of existing underground utilities and comply with the rules of the Blue Stakes of Utah 811.

1.06 TESTING FOR COMPACTION

A. Test for compaction as described in Section 31 23 00.

B. Where compaction tests indicate a failure to meet the specified compaction, the Contractor shall take additional tests every 10 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.

1.07 DEFINITIONS

A. PAVEMENT ZONE

1. The pavement zone includes the asphalt concrete and aggregate base pavement section placed over the street zone.

B. ROAD ZONE OR STREET ZONE

1. The road zone (street zone) is the top 12 inches of the trench immediately below the pavement zone in paved areas.

C. TRENCH ZONE

1. The trench zone includes the portion of the trench from the top of the pipe zone to the bottom of the street zone in paved areas or to the existing surface in unpaved areas or 6 inches below existing or finished grade where topsoil is required, unless noted otherwise.

D. PIPE ZONE

1. Unless noted otherwise, the pipe zone shall include the full width of trench from the bottom of the pipe base or bedding to a horizontal level above the top of the pipe, as specified below. Where multiple pipes or conduits are placed in the same trench, the pipe zone shall extend from the bottom of the lowest pipes to a horizontal level above the top of the highest or topmost pipe. Thickness of pipe zone above the highest top of pipe shall be as follows unless otherwise shown on Drawings or otherwise described in the Specifications for the particular type of pipe installed. For electric ducts and duct banks, trench wall clearances and pipe zone dimensions are shown on Drawings.

Pipe Diameter	Thickness of Pipe Zone Above Top of Pipe
6 inches or smaller	6 inches
8 inches and larger	12 inches

E. PIPE BASE OR BEDDING

1. The pipe base or bedding shall be defined as a layer of material immediately below the bottom of the pipe or conduit and extending across the full trench width in which the pipe is bedded. Thickness of pipe base shall be as follows unless otherwise shown on Drawings or otherwise described in the specifications for the particular type of pipe installed.

Pipe Diameter	Thickness of Pipe Base Below Bottom of Pipe
12 inches and smaller	4 inches
14 inches and larger	6 inches

PART 2 PRODUCTS

2.01 MATERIAL

A. Per Section 31 23 00, Excavation and Fill.

B. Marking tape and tracer wire:
   1. Fiber Optic Conduit Marking Tape: As provided by fiber optic conduit supplier.
   2. Marking Tape (Nondetectable):
      a. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
      b. Thickness: Minimum 4 mils.
      c. Width:(2) 6 inches for 24" larger pipe or (1) 6 inch for smaller pipe
      d. Color: Blue (for water) and Orange for Cathodic Protection test wires, green for storm and sanitary sewer, red for electrical wires, and yellow for gas.
      e. Lettering: Minimum 1-inch high, permanent black lettering imprint continuously over entire length.
         1) Text shall be:
            a) "High Pressure Waterline Buried Below" for water
            b) CP Test Wires" for cathodic protection wire.
            c) ""Buried Electrical Line Below" for electric wires.
            d) "Caution: Buried Gas Line" for gas.
            e) ""Buried Sewer Line Below" for sewer lines.
         2) Provide over other utilities exposed if utility owner requires.
         3) Install over all buried utilities.
      f. Manufacturers and Products:
         1) Reef Industries; Terra Tape.
         2) Allen; Markline.
   3. Tracer Wire:
      a. 12-gauge, copper, stranded UF, black 600V tracing wire.

PART 3 EXECUTION

3.01 GENERAL

A. Excavate and dispose of all materials of whatever nature encountered, including all obstructions that would interfere with the proper execution and completion of the Work. The removal of these materials shall conform to the lines and grades indicated or ordered.

B. Shoring system designer shall certify in writing that the excavation support systems are constructed per the applicable stamped, dated, and signed excavation support system of the designer including any modifications by Contractor during construction.

3.02 PROTECTION

A. Protect existing surface and subsurface features on-site and adjacent to site. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.

B. Protect existing utilities from damage or disturbance. Immediately notify utility whose facilities have been damage or disturbed. At utility owner's option, repair damaged utility or compensate utility owner for completed repairs.

C. Perform trenching and excavating operations in such a manner to protect personnel and the public from the dangers associated with trenching and excavation.

3.03 EXCAVATION

A. Follow applicable health and safety OSHA standards and requirements.

B. Remove rock, soil, organics, pavement, debris, trash, hard pan, loose shale, loose stone, and other obstructions as required to complete the Work or as directed by the Construction Manager.

C. Dewatering shall be in accordance with Section 31 23 19, Dewatering.
   1. Provide and maintain means and devices to remove and dispose of all water entering the trench excavation during the time the trench is being prepared for the pipe laying, during the laying of the pipe, and until the backfill at the pipe zone has been completed. Maintain groundwater 1 foot below the bottom of trench excavations and at an adequate lateral distance away from the trench slopes so as to have negligible effects on stability. Locate dewatering facilities such as deep wells and well points a minimum distance of one trench depth away from the trench.
   2. Open pumping from sumps shall not result in boils, softening of the ground, or loss of fines. These provisions shall apply 24 hours a day whenever pumping is performed. Dispose of the water in a manner to prevent damage to adjacent property and in accordance with regulatory agency requirements. Do not drain trench water through the pipeline under construction. Do not allow groundwater to rise around the pipe until jointing (welds and coatings) are complete.

D. Trench Excavation:
   1. Excavation is unclassified. Perform all excavation regardless of type, groundwater or other conditions per Section 31 23 00. Excavate the trench to the lines and grades shown on Drawings with allowance for pipe thickness, sheeting and shoring if used, and for pipe base or special bedding. If the trench is excavated beyond (horizontally or vertically) that required on Drawings and Specifications, refill any part of the over-excavated trench at no additional cost to the Owner with the same material required in the plans and specs, or foundation stabilization material, where required by the Construction Manager.
   2. Excavate trenches by open cut method to depth shown on Drawings and necessary to accommodate work.

a. Verify location of utilities and protect as necessary.
b. Support existing utility where proposed work crosses at a lower elevation.
c. Stabilize excavation to prevent undermining of existing utility.

3. Open trench limits:
   a. Limit length of open trench to no more than shown on the Drawings or specified.
   b. Reduce limits of open trench as weather conditions or groundwater infiltration dictate.
   c. At Owner's discretion, any excavation, trench, or portion of a trench which is opened and remains idle, shall be backfilled, if directed by the Construction Manager.
      1) If backfilled at Construction Manager's direction, trench or excavation may not be reopened until Construction Manager is satisfied that work associated with the trench or excavation will be performed immediately.
   d. Trenches left open must be protected from traffic and to prevent public access.
      1) Within unpaved areas limit the length of open trench to 500 feet in advance of pipe laying or the amount of pipe installed in one working day. Complete backfilling not more than 500 feet in the rear of pipe laying.
      2) Open trenches allowed within a traveled way (vehicular or pedestrian) or within 25 feet of a traveled way or occupied structure that is not barricaded off from the public traveled way using UDOT-approved jersey barriers shall be fully backfilled at the end of each day or covered with steel plates or other acceptable covers capable of supporting AASHTO HS-20 traffic loads. Maximum length of trench that may be covered with steel plates shall not exceed 200 feet.
4. Observe following trenching criteria:
   a. Trench size:
      1) Excavate width to provide adequate working room given the work area restrictions.
      2) Refer to drawings for trench maximum width dimensions. Comply with 29CFR Part 1926 Subpart P, Excavations. Trench width at the top of the trench will be limited to the width of the shoring for the excavation and should not undercut adjacent structures and footing. In such case, width of trench shall be such that there is at least 2 feet between the top edge of the trench and the structure or footing.
      3) Cut trench walls vertically from bottom of trench to minimum 1 foot above top of pipe.
      4) Keep trenches free of surface water runoff and groundwater seepage to a minimum 12 inches below the bottom of the trench, as required by Section 31 23 19, Dewatering.
5. Sloping, sheeting, shoring, and bracing of trenches:
   a. Trenches shall have sloping, sheeting, shoring, and bracing conforming with 29CFR1926, Subpart P - Excavations, OSHA requirements, and General Conditions.
   b. Provide shoring protection in accordance with Section 31 41 00 Sheeting, Shoring, and Bracing.

1) Shoring/bracing shall be designed and maintained so that soil does not migrate from behind the structural system creating voids. Shoring/bracing systems shall be removed such that compacted backfill is not disturbed.
2) Address ground settlement and utility shearing/settlement during installation and removal of shoring. If shoring methods are damaging utilities or services, change shoring methods or provide alternate construction methods so utilities and services are in acceptable and functional condition during and after construction.

6. Trench excavation in backfill and embankment areas:
   a. Conduct trenching in fill areas after primary settlement is achieved and rough grading completed.
   b. Where top of pipe is above existing grade, place and compact fills to 12 inches above top of pipe before excavating trench. Fills above top of pipe may be placed after pipe installation.
   c. Excavate trench in the compacted backfill or embankment. Place pipe base material, install pipe or conduit, and backfill with pipe zone material. Compact backfill above the pipe zone to the same relative compaction as the adjacent embankment as specified in Section 31 23 00, Earthwork.
7. Location of excavated material:
   a. See Drawings for designated stockpile areas.
   b. During trench excavation, place the excavated material only within the working area or within the construction and permanent easements and stockpile areas shown on Drawings unless letters of authorization from landowners (and land owner signed release forms at the end of the Project) are submitted to the Construction Manager authorizing work outside construction limits.
   c. Locate stockpiles for excavated trench materials outside of street rights of way. Do not obstruct any roadways or streets. Conform to federal, state, and local codes governing the safe loading of trenches with excavated material.
   d. Excavated topsoil shall be removed and stored separately. Unless otherwise noted, replace topsoil in the top 6 inches of the trench zone.
   e. Trench spoil piles shall be located at least 5 feet from the tops of the slopes of trenches. Cranes and other equipment shall not be operated on the same side of the trench as the spoil piles.
   f. Where natural cross-slopes exceed 15 degrees, trench spoil shall not be located uphill of the excavation unless stability is assessed through analysis by a registered professional engineer and authorized by the Construction Manager.
   g. Dispose of excess excavated native trench materials per Section 31 23 00.

3.04 PREPARATION OF FOUNDATION FOR PIPE LAYING

A. Regular Trench Excavation:
   1. Excavate minimum of 6 inches below bottom exterior surface of the pipe.
   2. Remove soft, loose, or previously disturbed or otherwise unsuitable material or soil from the bottom of the trench.
   3. Install pipe bedding material.
   4. Form welder access holes in trench bottom (if required).
   5. Support pipe.

B. Over-Excavation and Subgrade Stabilization:
   1. Observe the following requirements when unstable trench bottom materials are encountered.
      a. Notify Construction Manager when unstable materials are encountered.
      b. Remove unstable trench bottom.
      c. Backfill to the grade of the bottom of the pipe bedding with flowable fill material and compact.
   2. Any over-excavation carried below the grade ordered or indicated or if caused by Contractor's operations or failure to dewater or maintain a dry trench, shall be performed by the Contractor at no additional cost to the Owner.
   3. Over excavation, if field-initiated by Construction Manager, shall include the removal of all material that exists directly beneath the pipeline to a width 24 inches (minimum) greater than the pipe outside diameter and to the depth required.
      a. Backfill the trench to subgrade of pipe base with rock refill material for foundation stabilization. Place the foundation stabilization material over the full width of the trench and compact in layers not exceeding 8 inches deep to the required grade. Compact each layer with a track-hoe roller head to the satisfaction of the Construction Manager. Rock refill used by the Contractor for his/her convenience will not receive any additional payment.
      b. Where over excavation and rock refill are not required on Drawings, foundation stabilization work shall be executed only by change order when unacceptably soft (as determined by the Construction manager) subgrade materials are encountered in the trench. In such areas, after the required excavation has been completed, the Construction Manager will inspect the exposed subgrade to determine the need for any additional excavation. It is the intent that additional excavation be conducted in all areas within the influence of the pipeline where unacceptable materials exist at the exposed subgrade.

3.05 INSTALLING BURIED PIPING

A. Store, handle, and install pipe per the detailed piping specifications for the particular type of pipe, and per the following:
   1. Handle pipe in such a manner as to avoid damage to the pipe. Do not drop or dump pipe into trenches under any circumstances.
   2. Inspect each pipe and fitting before lowering the buried pipe or fitting into the trench. Inspect the interior and exterior protective coatings. Patch damaged areas in the field with material recommended by the protective coating manufacturer. Clean ends of pipe thoroughly. Remove foreign matter and dirt from inside of pipe and keep clean during and after installation.

B. Grade trench bottom to line and grade allowing for pipe thickness and bedding. Remove hard spots that would prevent a uniform bedding thickness. Place specified bedding thickness over full trench width. Grade and compact the top of bedding before pipelaying to provide firm, continuous, uniform support along full pipe length, and compact to the relative compaction specified. Before laying each section of the pipe, check the grade with a straightedge and correct any irregularities.
   1. Where CLSM backfill is used, provide sandbags to support the pipeline before CLSM placement.

C. Excavate bell hole at each joint to permit proper assembly and inspection of entire joint. Fill areas excavated for joints with CLSM.

D. Line and Grade: As shown on the Drawings.

E. After pipe has been bedded, place pipe zone material simultaneously on both sides of the pipe, in maximum 8-inch lifts, keeping the level of backfill the same on each side. Carefully place the material around the pipe so that the pipe barrel is completely supported and that no voids or uncompacted areas are left beneath the pipe. Use particular care in placing material on the underside of the pipe to prevent lateral movement during subsequent backfilling.

F. Compact each lift to the relative compaction specified herein. Compact trench backfill to the specified relative compaction. Compact by using mechanical compaction, or hand tamping.
   1. Compact material placed within 12 inches of the outer surface of the pipe by hand operated tampers or other equipment that will not damage the pipe.
   2. Do not use any axle-driven or tractor-drawn compaction equipment within 5 feet of building walls, foundations, and other structures.

G. Push the backfill material carefully onto the backfill previously placed in the pipe zone. Do not permit free fall of the material until at least 2 feet of cover is provided over the top of the pipe. Do not drop sharp, heavy pieces of material directly onto the pipe or the tamped material around the pipe. Do not operate heavy equipment over the pipe until at least 3 feet of backfill has been placed and compacted over the pipe.

H. When the pipelaying is not in progress, including the noon hours, close the open ends of pipe. Do not allow trench water, animals, or foreign material to enter the pipe.

I. Remove and dispose of all water entering the trench during the process of pipelaying. Keep the trench dry until the pipelaying and jointing are completed.

J. To avoid jarring pipe off grade, after setting (surveying) pipe to grade, do not MOVE shoring until after joint welding, coating and initial CLSM pipe zone set. After initial set, lift shoring panels to fill all shoring voids with CLSM and bring up backfill uniformly on both side of the pipe.

3.06 BACKFILLING METHODS

A. Do not backfill until tests to be performed on pipe show system is in full compliance with specifications.

B. Backfill shall be placed after all water is removed from the excavation, and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. Lift trench shields and trench boxes during placement of backfill. Ensure that each lift of backfill material makes full contact with earth trench sides prior to compacting the lift of backfill.

D. Pipe Zone:

1. The CONTRACTOR shall not proceed with bedding placement or pipe installation in excavated areas until the subgrade has been inspected.
2. Bedding material shall be placed in the bottom of the trench, leveled and compacted over the full width of the trench. Grade the top of the bedding ahead of the pipe laying to provide a firm, uniform support along the full length of pipe.
3. Backfill material shall be carefully placed and compacted around the pipe to ensure the pipe barrel is completely supported and that no voids or uncompacted areas are left beneath the pipe or below the haunches. Fill material shall be placed simultaneously on both sides of the pipe, keeping the level of backfill the same on each side.
4. Backfill around and over pipe shall be compacted using light hand operated, vibratory compactors and rollers. The use of a jetting and backhoe mounted compaction wheel is prohibited within the pipe zone above the top of the pipe. Care shall be exercised in placing material to prevent movement of the pipe during backfilling and to prevent gouging, denting or crushing of pipe or laterals.
5. Contractor shall be responsible for properly protecting pipe and appurtenances during backfill operations utilizing flowable backfill and providing measures as approved by the Construction Manager to prevent flotation.
6. Avoid displacing pipe joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.
7. Comply with pipe manufacturer's recommendations regarding backfilling and compaction.

E. Trench Zone and Final Backfill:
1. After the Pipe Zone material has been placed, compacted, inspected and accepted by the Construction Manager, backfill in the Trench Zone may proceed.
2. Care shall be exercised in the moving or removal of trench supports to prevent the caving or collapse of the excavation face. Voids between the native material, bedding and backfill must be filled and compacted to the satisfaction of the Construction Manager, UDOT, or Agency with jurisdiction of the right-of-way.
3. Place backfill in lift thicknesses capable of being compacted to density specified, but in no case exceeding 18-inch loose thickness.
4. Comply with pipe manufacturer's recommendations regarding backfilling and compaction.
5. Avoid displacing pipe joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.
6. Backfill to finished grade as shown on the Drawings and as follows:
    a. In paved areas, backfill shall be placed in accordance with requirements for pavement restoration.
    b. In unpaved or landscaped area, place topsoil as necessary to maintain the surface of the backfilled trench level with the adjacent ground surface.

F. Water flushing for consolidation is not permitted unless allowed in writing from Construction Manager.

G. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or as backfill material is being placed and compacted and then moving the shield horizontally.

Do not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

H. Cold weather limitations in placing fill and backfill
   1. Unless allowed in the authorized Cold Weather Construction Plan, earth fills and backfills requiring 95 percent or higher relative compaction shall not be placed when either atmospheric temperature, or the temperature of the existing ground or the fill being placed, are below 35 degrees Fahrenheit unless both the existing ground and the fill being placed are both non-frost susceptible materials.
   2. Earth fills and backfills requiring 90 percent or lower relative compaction may be placed when temperatures are below 35 degrees Fahrenheit if the required compaction is achieved. If the required compaction is not achieved, the work shall be removed and re-compacted.
   3. Do not place any fill or backfill materials which require 95 percent, or higher, relative compaction if the excavation or subgrade contains frozen moisture (snow, ice, sleet, etc.), frozen earthen materials, or earthen materials which have been deposited in the excavation due to freezing, thawing, precipitation, or other inappropriate means.
   4. Do not place fill materials which contain frozen moisture (snow, ice, sleet, etc.) except as allowed in the paragraphs above.
   5. Work performed outside the required temperature limitations is subject to rejection, removal and replacement.

I. Remove and replace any trenching and backfilling material which does not meet the Specifications, at the Contractor's expense.

3.07 COMPACTION REQUIREMENTS

A. Unless otherwise shown on Drawings or otherwise described in the Specifications for the particular type of pipe installed, relative compaction in pipe trenches shall be as follows (relative compaction values are per ASTM D1557 and per Section 31 23 00):
   1. Pipe Bedding (except CLSM): 90 percent relative compaction.
   2. Pipe Zone (except CLSM): 90 percent relative compaction.
   3. Backfill in Trench Zone not Beneath Paving: 95 percent relative compaction.
   4. Backfill in Trench Zone and Street Zone in Paved Areas: 95 percent relative compaction.
   5. Backfill in Pavement Zone under Asphalt: 95 percent relative compaction.
   6. Rock Refill for Contractor Over-excavation and for Foundation Stabilization: With a track-hoe roller head to the satisfaction of the Construction Manager.
   7. Topsoil Replaced: Match density of adjacent topsoil.
   8. Beneath Vaults, Manholes, and Other Structures: 95 percent relative compaction.
   9. All backfill placed soil for compaction shall be between 2 percent below and 2 percent above optimum moisture content unless noted otherwise.

3.08 PLACEMENT OF CLSM

A. The aggregate, cement, and water shall be proportioned either by weight or by volume. The water content shall be sufficient to produce a fluid, workable mix that will flow and

can be pumped without segregation of the aggregate while being placed. Prepare CLSM in accordance with ASTM C94.

B. Provide batching equipment to obtain the proper weights of soil, cement, water, and admixtures. All measuring devices should be sensitive to a 2 percent variation above or below the actual weights required. Volumetric batching may be used, provided the same accuracy required for weight batching is maintained.

C. Design and operate the mixers used for mixing the CLSM so that the CLSM as discharged from the mixer is uniform in composition and consistency throughout each batch.

D. Place the CLSM such that it flows easily into all open spaces and voids 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 be sure that the CLSM completely fills all open spaces and voids.

E. Lay the pipe on the sandbags and place the CLSM bedding as shown on Drawings. Bedding shall be placed under pipe from one side and vibrated, as necessary, so that it flows under the pipe until it appears on the other side. CLSM shall then be added to both sides of the pipe and vibrated 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 a way as to prevent uplift or buckling of the pipe.

F. Place CLSM into trench so it immediately fills voids left when shoring is removed. Do not place and compact pipe zone or trench zone backfill around the pipe until the CLSM has reached the initial set.

G. CLSM protection in freezing temperatures:
   1. If the ambient temperature is 40 degrees F or less, comply with the cold weather backfill and CLSM placement and curing requirements in Section 31 23 00, Earthwork.
   2. Whenever freezing temperatures are imminent, maintain the CLSM at a temperature of not less than 50 degrees F for 7 days after placement. The temperature of the mix shall be 50 degrees F or greater at the time of placement. The temperature shall be monitored 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 which may be required for protection of CLSM. Placement of CLSM shall be delayed until adequate provisions for protection against weather are made. No CLSM bedding shall be placed 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 INSTALLING MARKING TAPE AND TRACER WIRE

A. Install marking tape where shown in the trench details on Drawings. Secure marking tape to prevent movement during backfill. Marking tape is required over fiber optic ducts, water pipes, and cathodic test wires.

B. Tracer wire is required over all fiber optic, I&C, and electric ducts, and all pipelines except welded steel pipelines larger than 30-inches in diameter. Install atop the marking tape a

tracer wire and secure to prevent movement during backfill. Bring tracer wire to the surface every half mile in a testing/junction box.

C. Terminate tracer wire on a post mounted (or flush mounted) terminal. If the tracer wire terminals are acceptably labeled with securely attached bright yellow plastic tags, Construction Manager may allow them to be terminated on a cathodic test station post or in a pull box.

3.10 FIELD QUALITY ASSURANCE

A. Materials Testing:

1. The Owner shall perform and be responsible for all sampling and testing of materials as required for quality assurance/control of the Work. The Contractor shall pay for all costs associated with the day-to-day quality assurance/control to maintain all material within specified or approved limits. The Contractor shall retain a registered geotechnical engineer, independent from the Contractor, and a testing laboratory, whose qualifications are each acceptable to the Construction Manager by submittal, to perform all compliance testing described below. The Construction Manager may have an independent testing laboratory perform additional tests at no cost to the Contractor, however the Contractor shall provide materials for testing at no additional cost to the Owner.
2. Perform particle size analysis of soils and aggregates in accordance with ASTM C 136 Sieve Analysis of Fine and Coarse Aggregate and ASTM C 117 Materials Finer than No. 200 Sieve in Mineral Aggregate by Washing.
3. Determine sand equivalent in accordance with ASTM D 2419. Unified Soil Classification System: References to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487. The Contractor shall be bound by all applicable provisions of ASTM D 2487 in the interpretation of soil classifications.
4. Where soil material is required to be compacted to a percentage of maximum dry density, the maximum dry density at optimum moisture content will be determined in accordance with ASTM D 1557. In the field, determine the density of soil in place by the sand cone method, ASTM D 1556 or by nuclear methods, ASTM D 6938 and D 3017.
5. Apply rock correction factors as applicable. In case the test of the fill or backfill shows non-compliance with the required density, perform remedies as may be required to insure compliance. Subsequent testing to show compliance shall be by a testing laboratory selected by the Construction Manager and paid for by the Contractor.
6. Compaction tests shall be performed for each lift or layer. If nuclear methods are used for in-place density determination, verify the accuracy with one sand cone test, and one maximum laboratory dry density test, for every 2 weeks nuclear tests are used if the backfill material is processed fill or visually consistent. The Construction Manager shall be the sole judge of visual consistency. More sand cone and dry density tests will be required if the backfill material is visually variable. The minimum depth for the sand cone test hole shall be 8 inches. The minimum size shall be 8 inches and size 16/30 or 10/20 silica sand shall be used.
7. Determine laboratory moisture-density relations of soils by ASTM D 1557. If nuclear methods are used for in-place density determination, the compaction test results for maximum dry density and optimum water content shall be adjusted in accordance

with ASTM D 4718. This will be required for determination of percent relative compaction and moisture variation from optimum.

8. Determine the relative density of cohesion-less soils by ASTM D 4253 and D 4254. Sample backfill materials by ASTM D 75. "Relative Compaction" is the ratio, expressed as a percentage, of the in-place dry density to the laboratory maximum dry density.

B. Testing Frequency:

1. After an acceptable compaction procedure is established, compaction tests shall be taken at 300-foot intervals along the trench and at vertical intervals for every other lift at random locations and not necessarily vertical in line. A minimum of two tests will be required for each production day in the trench. Tests shall also be taken near structures, manholes, etc., and where designated by the Construction Manager. Embankment and fill areas shall have at least one compaction test performed each production day and no fewer than one test for each 1,000 cubic yards. Copies of all test reports shall be submitted to the Construction Manager by the next working day.
2. Location for compaction tests shall be prepared and submitted to the Construction Manager for approval prior to testing.
3. Compaction and other tests may be taken by the Construction Manager at intervals along the trench as described above to verify compliance with these requirements. Accommodate the Construction Manager in conducting these tests. Provide access and exploratory excavation as required to collect samples or conduct tests. Allot sufficient time during construction for the performance of any such compaction testing.
4. Compaction shall be deemed to comply with the specifications when no compaction test falls below the specified relative compaction. Pay the costs of any retesting of work not conforming to the specifications. Should the compaction methods used fail to achieve the required degree of compaction, revise compaction method to achieve the required compaction.
5. If a lift fails to meet the specified compaction requirements, remove and replace the backfill at proper density or bring the density up to specified level by other means acceptable to the Construction Manager. Pay for all subsequent tests required to confirm and verify that the reconstructed backfill has been brought up to specified density. Frequency of confirmation tests for remedial work shall be double that amount specified for initial confirmation tests.

C. Costs associated with necessary corrective work resulting from failed tests or inspections shall be paid by Contractor. Should any originally scheduled quality assurance test or inspection fail to meet requirements of the Contract Documents, the Contractor shall be responsible for the cost of retesting or re-inspection of Work including inspector’s and tester’s time and trips.

D. Should any compaction density test or subgrade inspection fail to meet requirements, perform corrective work as necessary to bring the material into conformance with the requirement of the Contract Documents.

END OF SECTION

SECTION 31 23 00

EXCAVATION AND FILL

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies earthwork which consists of but not limited to the following:
      a. Excavation
      b. Filling/backfilling
      c. Pipe bedding
      d. Flowable fill
      e. Aggregate basecourses
      f. Grading
      g. Disposal of excess material.

B. Definitions:
   1. Compaction: The degree of compaction is specified as percent compaction. Maximum or relative densities refer to dry soil densities obtainable at optimum moisture content.
   2. Excavation Slope: Excavation slope shall be defined as an inclined surface formed by removing material from below existing grade.
   3. Embankment Slope: Embankment slope shall be defined as an inclined surface formed by placement of material above existing grade.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM C136	Standard Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D1556	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D1557	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5-kg) Rammer and 18-in. (457-mm) Drop
ASTM D3017	Test Method for Moisture Content of Soil and Soil- Aggregate in Place by Nuclear Methods (Shallow Depth)
2017 APWA	Manual of Standard Specifications and Plans

B. Tests:
   1. The Construction Manager will take samples and perform moisture content, gradation, compaction, and density tests during placement of backfill materials to check compliance with these specifications. The Contractor shall remove surface material at locations designated by the Construction Manager and provide such assistance as necessary for sampling and testing. The Construction Manager may direct the Contractor to construct inspection trenches in compacted or consolidated backfill to determine that the Contractor has complied with these specifications. Payment for inspection trenches shall be as specified in the General Conditions of the Contract Documents_.
   2. Tests will be made by the Construction Manager in accordance with the following:

Test	Standard Procedure
Moisture content	ASTM D3017
Gradation	ASTM C136
Density in-place	ASTM D1556
Moisture-density relationships	ASTM D1557

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Samples of fill materials to be used shall be submitted 2 weeks in advance of use.

C. Submit a description and location of proposed sources of imported material.

D. Submit samples of all materials proposed to be used in the Work to demonstrate material conformance with these Specifications. Samples shall consist of 0.5 cubic feet of each type of material.

E. Test for conformance and submit certification and test records of all materials showing that they meet the applicable requirements. Obtain favorable review of test and certification submittals prior to commencing placement of the materials for the Work.

F. Product technical data including:
   1. Acknowledgement that products submitted meet requirements of standards referenced.
   2. Certified test results: Including, but not limited to gradation analysis, moisture density relationships, and in-place density test result reports on all materials tested.

3. Provide excavation support system submittal information in accordance with the following:
    a. Methods and sequencing of trench excavations.
    b. Proposed locations of stockpiled excavation and backfill material.
    c. Number, types, and sizes of equipment proposed to perform excavations.

1.04 SITE CONDITIONS

A. Avoid overloading excavation walls. Keep equipment and surcharge a sufficient distance back from edge of excavation to prevent slides or caving.

B. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and plant operations.

C. Protect and maintain benchmarks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

D. Verify location of existing underground utilities and comply with the rules of the Blue Stakes of Utah 811. Contractor shall provide a potholing plan to the Engineer.

E. Rock removal shall be performed in accordance with 2017 APWA Section 31 23 17, if applicable. Rock removal shall be limited to non-explosive methods. Rock removal shall be coordinated with the approval of the Engineer.

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. Type A: Sand
    1. Type A material shall be a clean gravel-sand mixture free from organic matter and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
3/4 inch	100
3/8 inch	70-100
No. 4	55-100
No. 10	35-95
No. 20	20-80
No. 40	0-55
No. 100	0-2

B. Type B: 3” Minus
    1. Type B material shall be a select granular material free from organic matter and of such size and gradation that the specified compaction can be readily attained. Material shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
3 inch	100
No. 4	35-100
No. 30	20-100

2. The coefficient of uniformity shall be 3 or greater.
3. The material may be an imported quarry waste, clean natural sand or gravel, select trench excavation or a mixture thereof.

C. Type C: Native
1. Type C material shall be unclassified material which is free from peat, wood, roots, bark, debris, garbage, rubbish or other extraneous material. The maximum size of stone shall not exceed 6 inches. If the material excavated from the site meets these requirements, it may be classified as Type C.

D. Type D: Pea Gravel
1. Type D material shall be granular material commonly known as pea gravel and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1/4 inch	100
No. 8	0-5

E. Type E: 1-1/2" Drain Rock
1. Type E material shall be crushed rock commonly known as drain rock and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1-1/2 inch	100
3/4 inch	30-75
1/2 inch	15-55
1/4 inch	0-5

2. Type E material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65

F. Type F: Road Base and/or ¾" Minus
1. Type F material shall be crushed rock and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1-1/2 inch	87-100
3/4 inch	45-90
No. 4	20-50
No. 30	6-29
No. 200	0-12

2. Type F material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.

G. Type G: Pervious Backfill

1. Type G material shall be pervious backfill. Pervious backfill material shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
3/8 inch	100
1/4-inch	50-100
1/8-inch	0-10
No. 200	0-2

H. Type H: 6" Riprap

1. Type H material shall be 6-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

Weight of stone	Percent smaller by weight
10 pounds	100
5 pounds	80-100
2 pounds	45-80
1 pound	15-45
1/2 pound	5-15
Below 1/2 pound	0-5

2. Specific gravity shall be between 2.5 and 2.82.

I. Type I: 12" Riprap

1. Type I material shall be 12-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

Weight of stone	Percent smaller by weight
160 pounds	100
100 pounds	80-100
50 pounds	45-80
20 pounds	15-45
5 pounds	5-15
1 pound	0-5

2. Specific gravity shall be between 2.5 and 2.82.

J. Type J:

1. Type J material shall be unclassified material and may be obtained from excavation on site. The material may contain extraneous material such as demolition waste, unsuitable material excavated from beneath structures, and clearing and grubbing debris up to 50 percent by volume. Extraneous material shall be thoroughly mixed and the maximum size of organic particles shall be 6 inches.

K. Type K: CLSM

1. Type K material shall be flowable fill (Controlled Low Strength Material, or CLSM)
2. CLSM shall consist of a mixture of Portland cement, aggregate, fly ash, water, and admixtures conforming to the following:

a. Portland Cement: ASTM C 150, Type II.
b. Aggregate: Concrete sand, or processed material from the excavations meeting the requirements of sand as herein specified. Aggregate size shall be maximum 3/8 inch and meet the requirements of ASTM C 33 for fine aggregate. The soluble sulfate content shall not exceed 0.3 percent by dry weight.
c. Water: Potable quality.
d. Fly Ash: Class F per ASTM C 618.
e. The minus 200 sieve fraction shall be non-plastic.

3. CLSM shall be flowable, non-segregating, self–consolidating and non-shrink
4. The unconfined compressive strength at 28 days shall be a minimum of 50 and a maximum of 150 psi per ASTM D 4832. For bidding, assume 100 pounds of cement and 100 pounds of fly ash per cubic yard of CLSM.
5. Sample CLSM at least once a day, four cylinders each time. Perform two cylinder breaks per four-cylinder sample at 7 days, the same as for concrete. Do not move cylinders for 72 hours after making.
6. The temperature of the CLSM discharged into the trench shall be below 70 degrees and above 45 degrees Fahrenheit.
7. The aggregate, cement, and water shall be proportioned either by weight or volume. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed. Prepare CLSM in accordance with ASTM C 94.
8. Water content shall match trial batch content. Do not add water after batching.

2.02 WATER FOR COMPACTION:

A. Water shall be free of organic materials, a pH of 7.0 to 9.0, a max chloride concentration of 200 mg/L, and a max sulfate concentration of 500 mg/L. Provide all work needed to transport water for earthwork including piping, valves, pumps and trucks, to convey water to the point of use.

PART 3 EXECUTION

3.01 GENERAL

A. Control of Water:
1. Construction dewatering for excavations shall be in accordance with the requirements of Section 31 23 19.
2. Maintain berms, sandbags, or other devices deemed appropriate by Engineer to divert or control surface runoff.
3. In no case shall runoff or construction water be allowed to enter the Creek.

3.02 SITE EXCAVATION

A. Overexcavation:
1. Where the undisturbed condition of natural soils is inadequate for support of the planned construction, the Construction Manager will direct the Contractor to overexcavate to adequate supporting soils. The excavated space shall be filled to the

specified elevation with backfill. The quantity and placement of such material will be paid for as extra work.

B. Surplus Material:
   1. Unless otherwise specified by the Owner, surplus excavated material shall be disposed of off site in accordance with applicable ordinances and environmental requirements.
   2. Material shall not be stockpiled to a depth greater than 5 feet above finished grade within 25 feet of any excavation or structure except for those areas designated to be preconsolidated. For these areas, the depth of stockpiled material shall be as specified. The Contractor shall maintain stability of the soil adjacent to any excavation.

C. Borrow Material:

   If the quantity of acceptable material from excavation is not sufficient to construct the work, the quantity of material needed to complete the work shall consist of imported borrow conforming to specified requirements.

D. Hauling:
   1. When hauling is done over highways or city streets, the loads shall be trimmed and the vehicle shelf areas shall be cleaned after each loading. The loads shall be watered after trimming to eliminate dust.

E. Haul Roads:
   1. The Contractor shall construct haul roads required to transport materials on site. Alignment of haul roads shall be selected to avoid interference with plant operations. Haul roads shall be removed after completion of embankment construction.

F. Finish Grading:
   1. Finished surfaces shall be smooth, compacted, and free from irregularities. The degree of finish shall be that normally obtainable with a blade-grader.
   2. Finished grade shall be as specified by the contours plus or minus 0.10 foot except where a local change in elevation is required to match sidewalks, curbs, manholes and catch basins, or to ensure proper drainage. Allowance for topsoil and grass cover, or subbase and pavement thickness shall be made so that the specified thickness of topsoil or pavement section can be applied to attain the finished grade.
   3. When the work is an intermediate stage of completion, the lines and grades shall be as specified plus or minus 0.5 foot to provide adequate drainage.
   4. Protection of Finish Grade:
      a. During construction, shape and drain excavations.
      b. Maintain ditches and drains to provide drainage at all times.
      c. Protect graded areas against action of elements prior to acceptance of work.
      d. Reestablish grade where settlement or erosion occurs.

G. Control Of Erosion:
   1. The Contractor shall maintain earthwork surfaces true and smooth and protected from erosion. Where erosion occurs, the Contractor shall provide fill or shall excavate

as necessary to return earthwork surfaces to the grade and finish specified. Surfaces shall be maintained to divert runoff away from the Creek.

3.03 PROTECTION

1. Protect existing surface and subsurface features on-site and adjacent to site. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.
2. Protect existing utilities from damage or disturbance. Immediately notify utility whose facilities have been damage or disturbed. At the utility owner's option, repair damaged utilities or compensate utility owner for completing the repairs.

3.04 CLASSIFICATION OF FILL

A. Fill material shall be placed in horizontal layers and compacted with power-operated tampers, rollers, idlers, or vibratory equipment. Material type, maximum layer depth, relative compaction, and general application are specified in Table A. Unless otherwise specified, fill classes shall be used where specified in Table A under general application.

Table A, Fill Classifications

Fill class	Material type	Maximum uncompressed layer depth, inches	Minimum relative compaction, percent	General application
A1	A	8	95	Bedding for pipe, initial pipeline backfill; slabs on grade (other than specified for Class E1)
A2	A	48	95	Initial and subsequent pipeline backfill when ponded or jetted
B1	B	8	95	Structure and subsequent pipeline backfill
B2	B	8	90	Site fill
C1	C	8	90-95	Subsequent pipeline backfill; compaction as specified
C2	C	8	90	Site fill, embankments and dikes
D1	D	-	95	Bedding for tanks and pipe, initial and subsequent tank and pipeline backfill
E1	E	8	-	Site Laydown and road widening areas, Trench Foundation, Fill under slabs for structures and tank slabs with pressure relief valves. Drainage Swales and Ditches
F1	F	12	95	Structure backfill, pipeline bedding, initial and subsequent pipeline backfill
G1	G	8	95	Bedding for plastic pipe, initial and subsequent pipeline backfill
H1	H	-	-	Embankment slope face, channel slope face
I1	I	-	-	Embankment slope face, channel slope face
J1	J	8	90	Excess fill
K1	K	-	-	Substitute fill for unsuitable soils or areas where there is less than 12" of clearance between utilities.

3.05 A. EARTHWORK FOR STRUCTURES

A. Structure Excavation:

1. The bottom shall not be more than 0.15 foot above or below the lines and grades specified. If the elevation of structure excavation is not specified, the excavation shall be not more than 0.15 foot above or below the elevation specified for fill material below the structure. Slopes shall vary no more than 0.5 foot from specified grade unless the excavation is in rock where the maximum variation shall be 2 feet.
2. Should the excavation be carried below the lines and grades specified on the drawings or should the bottom of the excavation be disturbed because of the Contractor's operations and require overexcavation and backfill, the Contractor shall refill such excavated space to the proper elevation in accordance with the procedure specified for backfill. The cost of such work shall be borne by the Contractor.
3. Unless otherwise specified, excavations shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services, and for inspection, except where concrete is specified to be placed directly against excavated surfaces.

B. Foundation Treatment:

1. Rock foundations for concrete or masonry footings shall be excavated to sound material. The rock shall be roughly leveled or cut to steps and shall be roughened. Seams in the rock shall be grouted under pressure as directed by the Construction Manager and paid for as extra work.
2. When footings are to be supported on piles, excavations shall be completed to the bottom of the footings before any piles are drilled or driven therein. When swell or subsidence results from driving piles, the Contractor shall excavate, or backfill the footing area to the grade of the bottom of the footing with suitable material as specified. If material under footings is such that it would mix into the concrete during footing placement or would not support the weight of the fluid concrete, the Contractor shall replace the material with suitable material, install soffit forms or otherwise provide a suitable platform on which to cast the footing as directed by the Construction Manager. This shall be paid for as extra work.
3. Whenever any structure excavation is substantially completed to grade, the Contractor shall notify the Construction Manager who will make an inspection of the subgrade. Subgrade treatment shall not commence until subgrade has been approved by the Construction Manager.
4. No concrete or masonry shall be placed until the foundation contact has been inspected by the Construction Manager. The Contractor shall, if directed by the Construction Manager, dig test pits and make test borings and foundation bearing tests. If the material tested is undisturbed soil, the cost thereof will be paid for as extra work. If the material tested is backfill material, the cost thereof will be paid as specified in the General Conditions of the Contract Documents.

C. Subgrade Treatment:

1. One foot of Type E material shall be placed above all native materials. A layer of geotextile fabric (Mirafi 270 or equal) shall be placed between the native material and the Type E material.
2. A layer of geotextile fabric (Mirafi 270 or equal) shall be placed between other materials that could migrate into the Type E material.

3. Whenever any structure excavation is substantially completed to grade, the Contractor shall notify the Construction Manager who will make an inspection of the subgrade. Subgrade treatment shall not commence until subgrade has been approved by the Construction Manager.
4. No concrete or masonry shall be placed until the foundation contact has been inspected by the Construction Manager. The Contractor shall, if directed by the Construction Manager, dig test pits and make test borings and foundation bearing tests. If the material tested is undisturbed soil, the cost thereof will be paid for as extra work. If the material tested is backfill material, the cost thereof will be paid as specified in the General Conditions of the Contract Documents.

D. Structure Backfill:
1. Unless otherwise specified, structure backfill shall be Class B1.
2. After completion of construction below the elevation of the final grade, and prior to backfilling, forms shall be removed and the excavation shall be cleaned of debris.
3. Structure backfill shall not be placed until the subgrade portions of the structure have been inspected by the Construction Manager. No backfill material shall be deposited against concrete structures until the concrete has developed a strength of not less than 75 percent of the minimum 28-day compressive strength.
4. Do not operate earthmoving equipment within 5 feet of any concrete structure. Structural backfill shall not be placed until the concrete has developed to at least 75 percent of the minimum 28-day compressive strength, and in all cases not less than 24 hours after the last pour.
5. Place structural backfill material around structures, channels, vaults, manholes, and other structures to the lines and grades shown or specified. If hand compaction equipment is used, limit loose lift depths to 6-inches or less.
6. Place and compact fill or backfill adjacent to concrete structures using hand-operated tampers, roller wheels, or other equipment that shall not damage structure
7. Compact each lift as hereinafter specified. Stop structural backfill at least 6 inches below finished grade in areas where topsoil is to be replaced.
8. Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure.
9. Compaction of structure backfill shall not be performed by ponding and jetting.
10. Unless otherwise specified, backfill around and above pipelines within the excavation line of any structure shall be the same as that specified for structures.

3.06 EARTHWORK FOR PIPELINES AND CONDUITS

A. Earthwork for Pipelines and Conduits shall be performed in accordance with Section 31 21 33 Trenching, Backfilling, and Compacting for Utilities.

B. Materials:
1. Trench Foundation:
a. Flowable fill (CLSM) where shown on the drawings..
b. Fill Class F1 unless otherwise specified.
2. Pipe Bedding and Pipe Zone:
a. Provide concrete encasement for all piping and conduits located below structures as indicated in the Drawings.

b. Flowable fill (CLSM) where shown on the drawings. Use flowable fill to backfill the space above the excavated subgrade and the bottom of pipe zone. Also use flowable fill to backfill the pipe zone of piping where vertical separation between other piping is less than 12 inches.
c. General Piping: Fill Class A1
d. Plastic piping less than 2-inches in diameter and direct buried electrical or control conduits: Fill Class G1
e. Perimeter drain pipe: Drain sand.

3. Trench Zone:
   a. Flowable fill (CLSM) where shown on the drawings.
   b. Beneath AC paved roads and road shoulders: Fill Class F1
   c. Other Locations: Native material excavated from the project trenches which is free from organic matter, nested cobbles 3-inches or larger, or other deleterious matter and meeting the requirements for earth fill as specified.
      1) If Contractor cannot achieve the required trench zone compaction with the native material excavated from the project trenches, then Contractor shall use an imported material, or another material acceptable to the Construction Manager.
4. Final Backfill:
   a. Beneath AC paved roads and road shoulders: Fill Class F1
   b. Other Locations: Six (6) inches of topsoil

3.07 PLACING AND COMPACTING FILL

A. Remove form materials and trash from excavation before placing fill material. Remove uncompacted fill, loose and disturbed soils until firm soils or formational material are exposed. Removed materials may be used as compacted fill if they meet specifications.

B. Under earth fills, scarify the exposed surface to a depth of 6 inches, moisture condition to within 2 percent of optimum moisture content, and compact to at least 95 percent relative compaction.

C. Obtain Construction Manager inspection and authorization to begin backfill on the exposed surface before starting placement of fill.

D. Add water to the backfill material or dry the material, as necessary, to obtain a moisture content within 2 percent of optimum. Obtain a uniform moisture content throughout the material of each layer being compacted.

E. If the backfill material is saturated from groundwater, rains or any other source, remove and replace the unsatisfactory material with suitable material compacted to the specified density. No additional payment will be made for removal and replacement of unsatisfactory material.

F. Where earth fills are to be constructed on slopes steeper than 5:1, excavate an equipment width keyway beneath the toe at the base of the fill. The keyway will have a minimum width of 10 feet and slope at least 2 percent into the slope. Continue benching into competent material as the fill progresses up slope. All benching shall be inspected and authorized by the Construction Manager before fill placement begins.

G. Place all fills in 6- to 8-inch lifts, brought to within 2 percent of optimum moisture content, and compacted to 90 percent relative compaction (except as specified under "Trench Backfill and Compaction". Do not place rocks larger than 6 inches in maximum dimension in the fills.

H. Provide special attention to compaction along the top and outer edge of the earth fill slopes during construction. Backroll fill slopes after each fill lift is completed. Perform additional rolling and trimming as may be required at the finish of the slope construction to correct local surficial slumping

3.08 SUBGRADE FOR PAVEMENT

A. The prepared subgrade shall be scarified to a depth of at least 12 inches and recompacted to at least 95 percent of the maximum density based on ASTM D 1557.

B. Contractor shall use Class F1 unless specified in the drawings.

3.09 SITE FILL

A. Unless otherwise specified, site fill shall be Class C2 fill. If the existing slope in an area to be filled is greater than 5:1, the Contractor shall bench the area prior to filling.

3.10 GROUTING RIPRAP

A. When riprap is properly positioned, stones shall be flushed with water to remove fines sweep. After Contractor shall sweep sand or fine gravel into the interstices to fill to within four (4) inches of the outer surface of the riprap.

B. Fill the remaining volume of the interstices flush with a well-mixed grout. Grout shall be applied in two courses using baffles and diverting equipment. The first course shall completely penetrate the stone voids and shall be applied with the aid of poles or rods to loosen the tight pockets of stone. The second course shall be applied as soon as the first course has jelled. The second course shall be broomed uphill during application, and the entire surface shall be rebroomed to eliminate runs and fill voids.

C. Keep grout wet by sprinkling or covering with wet material for at least three (3) days. Protect grout from stream water or any other disturbance during this cure period.

D. Do no place grout in freezing weather.

E. After grouting is complete, no load shall be permitted on the grouted surface for 24 hours. The grouted surface shall be protected from damage until curing is complete.

3.11 COLD WEATHER LIMITATIONS IN PLACING FILL AND BACKFILL

A. Unless allowed in the authorized Cold Weather Construction Plan, earth fills and backfills shall not be placed when either atmospheric temperature, or the temperature of the existing ground or the fill being placed, are below 35 degrees Fahrenheit unless both the existing ground and the fill being placed are both non-frost susceptible materials.

B. Do not place any fill or backfill materials on subgrade which contains frozen moisture (snow, ice, sleet, etc.), frozen earthen materials, or earthen materials which have been

deposited in the excavation due to freezing, thawing, precipitation, or other inappropriate means.

C. Do not place fill materials which contain frozen moisture (snow, ice, sleet, etc.).

D. Work performed outside the required temperature limitations is subject to rejection, removal and replacement.

3.12 STOCKPILE LIMITATIONS AND DISPOSAL OF EXCAVATED MATERIAL

A. Confine stockpiles to the areas designated in the Contract Drawings.

B. Prevent dust from damaging homes, businesses, public and private facilities, crops, cultivated fields, and other improvements, or causing a nuisance to persons. Perform dust control for the duration of the project.

C. Legally dispose of all excavated materials unsuitable for backfill, and other unused excavated materials. Excavated materials suitable for backfill may temporarily be stored at the site so-as not to interfere with public traffic or concurrent work or to mix with other stockpiled material.

D. Notify the Construction Manager immediately if contaminated soils are found on the project.

E. Provide adequate facilities for drainage of water from stockpiled excavated material and adequate facilities for handling of storm drainage from storage and other areas. Do not allow runoff water to enter the Creek.

END OF SECTION

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SECTION 31 23 19

DEWATERING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the requirements for the installation, maintenance, operation, and removal of dewatering systems, and all Work necessary to control, handle, satisfactorily treat, if required, and dispose of groundwater and surface water, and all other water including construction-generated water that may be encountered, as required for performance of the Work.

B. Dewatering of trenches and other excavations will not be measured and paid for separately but will be considered as incidental to performance of the Work.

1.02 DEFINITIONS

A. Construction-Generated Wastewater: Groundwater, surface water, precipitation, water generated from maintenance or cleaning of equipment, and all other water collected in dewatering systems associated with the Work.

1.03 REFERENCES

A. Referenced Standards: This Section incorporates by reference the latest revision of the following documents. These references are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

1. Environmental Protection Agency (EPA):
   a. 40 *Code of Federal Regulations* (CFR) 136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants
   b. 40 CFR 261 - Identification and Listing of Hazardous Waste
   c. 40 CFR 403 - General Pretreatment Regulations for Existing and New Sources of Pollution
2. Utah Administrative Code and Utah Department of Environmental Quality, Division of Water Quality
3. Utah Department of Environmental Quality Best Management Practices

1.04 QUALIFICATIONS:

A. Sumping systems within the trench may be designed by the Contractor or the Contractor's dewatering system designer.

B. For external dewatering systems such as wellpoints or extraction wells, the system(s) designer shall be a Registered Geologist, Certified Engineering Geologist, or professional engineer registered in the State of Utah, having a minimum of five (5) years of dewatering experience similar in type and scope. The exception is for an experienced, professional hydrogeologist with at least ten (10) years' experience designing similar

external dewatering systems. The designer shall have experience dewatering systems similar in type and scope.

1.05 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Groundwater Control Plan (GWCP) to include:

1. Submit the plan to the Construction Manager at least 15 working days before beginning work.
2. The plan shall include a narrative of the type of dewatering system or systems proposed with a discussion of how the system may be modified or augmented in order to handle more flow or increase drawdown of the water table. Show the pump types and sizes selected, header surface piping layout, primary and backup power systems, details of discharge piping if crossing roads including methods of protecting the pipe and traffic and other related information.
3. The plan shall show the proposed route of the discharge pipeline compatible with the Contractor's work plan, and the discharge point. The proposed route shall be approved by the Owner.
4. The plan shall also contain a narrative description of the installation sequence and methods as well as operation and maintenance procedures and observation of groundwater levels.
5. The plan shall also include a narrative description that describes the procedure and timing of decommissioning the dewatering system including final abandonment of groundwater control wells and groundwater observation wells.
6. Include drawings and complete design analytical methods for the external and internal trench systems, including system equipment and installation and abandonment (with identified licensed well driller) and observation well typical materials such as screens, riser pipe, filters/and sand packs, and installation.
7. The plan shall also include details on collected water treatment facilities as needed and methods to dispose of the collected water.

C. Product Data:

1. Manufacturer's catalogs for proposed equipment detailing the basis of operation, operating and maintenance instructions and manuals, product descriptions, and ratings in terms of size and capacity.
2. Manufacturer catalogs for proposed materials, and supplies identifying their type, description, and properties.
3. Calibration documentation for flow meters.

D. Contractor shall be responsible to identify and secure permits required. Contractor shall obtain and submit a groundwater discharge permit from Utah Division of Environmental Quality (UDEQ) prior to any groundwater discharge.

1. CONTRACTOR is responsible for obtaining said permit from the UDEQ and performing any sampling and laboratory analyses required as part of permit compliance.
2. Submit all correspondence and permits with the Utah Department of Environmental Quality regarding dewatering operations, including but not limited to the authorization to drill, well driller's license, and completion report.

E. Dewatering system designer qualifications. Include a list of past groundwater control projects during the past five (5) years showing date of work, location, project name and Owner, and type of groundwater control system(s) used.

F. Drilling logs and well diagrams:

1. Submit drilling logs that include the following:
   a. Drilling method(s).
   b. Location numbering.
   c. Surface elevation.
   d. Drilling conditions.
   e. Soil descriptions.
   f. Groundwater conditions.
   g. Borehole depth.
2. Provide descriptions of filter pack material to be used in pumped groundwater control wells and groundwater observation wells that include manufacturer's or supplier's statement that material is free of clay, silt, dirt, organic or other foreign matter.

G. Groundwater control and groundwater observation well decommissioning documentation.

H. Evidence of State of Utah license for well driller responsible for installation and abandonment of wells, well points, and observation wells.

1.06 SITE CONDITIONS

A. Methods of dewatering will be determined by the Contractor.

B. Locate dewatering facilities where they shall not interfere with utilities and construction work to be performed by others.

C. Modify dewatering procedures which cause, or threaten to cause, damage to new or existing facilities, so as to prevent further damage. Control the rate of dewatering to avoid all objectionable settlement and subsidence.

D. Where critical structures or facilities exist immediately adjacent to areas of proposed dewatering, reference points shall be established and observed at daily intervals by a Professional Land Surveyor of the State of Utah to detect settlement that may develop.

1. Conduct dewatering operation in a manner that will protect adjacent structures and facilities.
2. Repair damage to adjacent structures and restore facilities at no expense to OWNER.
3. Submit initial and weekly test results.

E. Comply with all applicable requirements and provisions of local, federal and/or state laws or regulations. Obtain authorization, as required, prior to discharge of groundwater, and comply with the sampling, testing, monitoring, and reporting requirements specified therein.

1.07 DESIGN CRITERIA

A. General:

1. Design surface drainage to intercept and divert away from the Work site and in accordance with Section 31 23 00, Earthwork.
2. Design facilities to adequately collect, handle, and treat flows, and to discharge water of the minimum quality required by local, State, and Federal regulations and applicable permits.
3. Dewatering activities shall be in compliance with the requirements of the Utah Administrative Code and Utah Department of Environmental Quality, Division of Water Quality.
4. Handle and dispose of water in such manner as shall not damage property or create nuisance or safety concerns.
5. Dispose of water from site at such rates that do not exceed capacity of the receiving systems.

B. Other Discharge Requirements:

1. Do not discharge waters exhibiting visible oil, grease, trash and/or other hazardous substances.
2. Prevent odors, vectors, and other nuisances of waste origin beyond Work limits.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish and maintain all materials, tools, equipment, facilities, and services as required for providing the necessary dewatering Work and facilities.

PART 3 EXECUTION

3.01 DEWATERING

A. Dewatering systems shall be installed to collect, treat, and dispose of all surface water, perched water, water migrating along existing buried utilities, and groundwater that enters excavations, trenches, or other parts of the Work.

B. Contractor shall assume complete responsibility for prevention of damage to the existing facilities from potential settlement caused by the dewatering operation. The Contractor shall assume full responsibility for mitigation of these damages at no additional costs to the Owner.

C. All excavations shall be kept free from water and all construction shall be in the dry.

1. It should be presumed that the presence of groundwater will require dewatering operations. A well point system or other acceptable dewatering method may be required in certain locations. Furnish, install, maintain, and operate all necessary pumping and other equipment for dewatering all excavations. At all times have on the project sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable.

2. Provide a sufficient number of pumps so as to hold the groundwater level at an elevation of not less than 1 foot below the lowest elevation of the trench, excavation, material to be placed.
3. Dewatering operations shall start and continue sufficiently in advance of the excavation to ensure that all water in the soil above and to the side of the excavation is free of water and that the hydrostatic pore pressure has been relieved.
4. Dispose of water in such a manner as to cause no injury or nuisance to public or private property or be a menace to the public health.
5. The dewatering operation shall be continuous, so that the excavated areas shall be kept free from water during construction, while concrete is setting and achieves full strength, and until backfill has been placed to a sufficient height to anchor the Work against possible flotation.
6. Continue dewatering during backfilling operations such that the groundwater is at least 1 foot below the level of the compaction effort at all times. No compaction of saturated materials will be allowed.
7. Dewatering devices must be adequately filtered to prevent the removal of fines from the soil.
8. The Contractor shall be responsible for any damage to the foundations or any other parts of existing structures or of the new Work caused by failure of any part of the Contractor's protective works. After temporary protective works are no longer needed for dewatering purposes, they shall be removed by the Contractor.
9. If pumping is required on a 24-hour basis, requiring engine drives, then engines shall be equipped in a manner to keep noise to a minimum and below the noise level requirements of applicable permits.
10. Prevent disposal of sediments from the soils to adjacent lands or waterways by employing whatever methods are necessary, including settling basins. Refer to 01 57 23 Temporary Storm Water Pollution Control.

D. Promptly remove and dispose of all excess water entering the trench from the time the trench is being prepared for the pipe laying and until the backfill at the pipe zone has been completed. Dispose of the water in an approved manner without damage to adjacent property.

E. Control groundwater to prevent softening of the bottom of excavations or formation of "quick" conditions or "boils." Design and operate dewatering systems to prevent migration or removal of the natural soils and so that the groundwater level outside the excavation is not reduced to the extent that would damage or endanger adjacent structures or property.

F. When dewatering near a river, lake, or stream, conform to the requirements of applicable permits. When the presence of water or other conditions in the excavated area would be detrimental to the purpose of the Work, obtain approval of the Construction Manager for the temporary measures required to correct or care for the condition.

G. If water or other conditions encountered require permanent correction or care not anticipated by the Contract and not due to the Contractor's neglect or method of operation, immediately notify the Construction Manager.

H. At all times have on hand sufficient pumping equipment and machinery in good working condition for all ordinary emergencies, including power outages. Have available at all times competent workmen for operation of the pumping equipment. Control surface runoff to prevent entry or collection of water in excavations. Keep all excavations free of water when concrete is being deposited or during placement of backfill.

I. Release ground water to its static level in such a manner as to maintain the undisturbed state of natural foundation soils. Prevent disturbance of compacted backfill and flotation or movement of structures, water mains, sewers, and other utilities.

3.02 DISCHARGE OF CONSTRUCTION GENERATED WASTEWATER

A. Manage discharge of construction-generated wastewater into a public sewer, public sump, or body of surface water as required by Construction Manager and/or permitting agency/agencies. Plans shall cover all Work necessary to design, permit, provide, operate, maintain, monitor, restore and remove all machinery, appliances and equipment required to perform this Work.

B. Discharge Permit

1. Apply for and obtain a wastewater Discharge Permit(s) from the regulating agencies before discharging any wastewater into a public sewer, public sump, or body of surface water. Do not begin discharge until the appropriate permitting agency/agencies has reviewed the Discharge Permit application and has issued written authorization to proceed including any specific conditions that apply. All applications shall include a copy of the proposed GWCP and, if applicable, a copy of the project environmental site assessment.
2. The approved Discharge Permit may restrict discharge of wastewater to a quantity containing less than a specified maximum daily load for a distinct set of parameters such as Total Dissolved Solids (TDS) or Total Suspended Solids (TSS). Any specified daily load limits will apply to the project as a whole and not to individual discharge location(s) unless otherwise specified. Limits specified by the Discharge Permit will be determined based on likely site pollutants and/or pollutants of concern for the receiving system. Design, operate, and maintain a containment and discharge system to control the flow rate, solids, or other pollutants in accordance with limitations specified by the applicable Discharge Permit.

C. Groundwater Control Plan Modifications

1. Upon discovery or receipt of notice that any discharge exceeds GWCP limitations, immediately stop all discharge, modify the process described in the GWCP and submit a GWCP modification proposal for review.
2. If breakdown, accident, acts of nature, or any other condition cause the release of any pollutant, excessive solids load or wastewater volume, take the following actions:
   a. Immediately take action to stop, contain, and correct the problem.
   b. Immediately notify the Construction Manager.
   c. Within five (5) calendar days after such a noncompliance event, submit a detailed written report describing the breakdown, the actual quantity of resultant wastewater discharged, the corrective action taken, the steps taken to prevent

recurrence, proposed GWCP modifications, if necessary, and any other pertinent information.

d. Implement all approved corrective measures and retest the discharge system before restarting any operations. The Construction Manager will observe all retesting and review the system for use. If necessary, modify discharge operations during unusually severe weather conditions or as directed.

D. Design and Construction

1. Design and select materials and equipment for implementing the GWCP in a manner that will yield compliance with the Discharge Permit. Incorporate equipment and/or procedures to record total daily discharges.
2. Install properly sized totalizing flow meters on all pumps to accurately log the total daily discharge volume. Do not install flow meters closer than four feet from any bend in the pump discharge line.
3. As an alternative, record the total number and volume of all storage tanks filled throughout a workday. Calculate average flow rate by recording the time, in minutes, to empty each tank after it has been filled and the contents have been sampled. Make sure there is adequate number of storage facilities on site to assure that none of the wastewater is directly discharged without being held for sampling.
4. Install and maintain fittings for sampling purposes in all of the discharge line(s). Locate fittings downstream of storage facilities but upstream from the approved disposal locations(s). Fittings shall be fully accessible and provide the Construction Manager opportunity to safely obtain one-liter samples of wastewater. Detail sampling locations in the GWCP.

E. Operation

1. Give one (1) working days notice before initiating discharge operations. Record daily total amount of wastewater discharged at all location(s). Submit a weekly report to the Construction Manager summarizing discharge rates and volumes at each location(s) for the previous seven calendar days.
2. From time to time, the Construction Manager will collect and analyze representative samples from all discharge location(s). Samples will be taken downstream from any storage or treatment facility. Sampling will continue throughout wastewater discharge. Samples will frequently be taken on random occasions and frequency will change without notice.
3. Provide the previous day total discharge at each sample location(s). The Construction Manager will report sample analyses to the Contractor within 72 hours after sample results are available. During this' time, do not modify the discharge method or its operation without approval.
4. Retain all records relating to the Discharge Permit for a minimum of three (3) years after Acceptance and Final Payment. Extend this retention throughout the course of any unresolved litigation pertaining to the discharge of pollutants, or when a regulatory authority (e.g., DEQ or EPA) requests this information.
5. Pretreat all wastewater containing solids or pollutant concentrations exceeding, the specified maximum Daily Load limit(s). Dispose of all wastewater in such manner as to prevent injury to public or private property or nuisance or menace to the public. Control the entry or collection of surface runoff to prevent contamination of discharged wastewater. Pipe all wastewater from the site to the approved discharge

point(s). Do not convey any wastewater in open ditches or trenches. Protect all pipe outlets to avoid damage at the discharge location.

F. Enforcement

1. The Discharge Permittee will be solely responsible for any civil penalties that may be assessed for any violation of the Discharge Permit or Discharge Authorization conditions.

3.03 SYSTEM PROTECTION

A. Take all reasonable and necessary precautions to provide continuous and successful system operation.

B. Clearly mark and protect all pumped groundwater control wells, header pipes, discharge lines, observation wells, and other system components to prevent damage from vehicles or equipment.

3.04 SYSTEM DECOMMISSIONING AND REMOVAL

A. The Contractor shall employ Utah State licensed well drillers for the abandonment of wellpoints, wells, observation wells and other dewatering facilities in accordance with applicable regulations. Contractor is responsible for the abandonment of all new installations done by the Contractor.

B. The Contractor shall not abandon or remove any wellpoints, wells, observation wells, piezometers, or other dewatering and groundwater control systems without prior written authorization of the Construction Manager, and shall provide Construction Manager minimum 24-hour notice prior to abandonment.

C. The Contractor shall submit written documentation of abandonment of all wellpoints, wells, observation wells, piezometers, or other similar penetrations below the ground surface including unique identification number, location coordinates, date and time of abandonment, the names of the Contractor's personnel performing the abandonment and the Construction Manager observing the abandonment.

D. Cost of abandonment shall be considered incidental to the Work or included in contractual unit prices as appropriate.

E. Continue dewatering during backfilling operations to meet requirements above and including no compaction of saturated materials above the trench foundation material or granular fill under structures.

F. Dispose of all surface water runoff and water removed by the dewatering system in an environmentally sound and legal manner that will not endanger health, property, or any portion of the Work. The discharge locations shall be identified in the Contractor's GWCP submittal.

G. Install groundwater monitoring wells as necessary.

H. Shut off dewatering system at a slow rate to prevent a quick upsurge of water that might weaken the subgrade.

END OF SECTION

SECTION 31 26 20

FILTER FABRIC

GENERAL

1.01 SUMMARY

A. Section includes: Nonwoven filter fabric.

PART 1

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 4491 - Standard Test Method for Water Permeability of Geotextiles by Permittivity.
   2. D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   3. D 5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.03 DEFINITIONS

A. Filter fabric: Nonwoven geotextile fabric manufactured from polypropylene fibers.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

PART 2

A. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PRODUCTS

A. Specified on design drawings

EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of filter fabric.

PART 3

3.02 PREPARATION

A. Surface preparation:

During grading operations, take care not to disturb the subgrade.

1. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented herein.

B. Place the filter fabric smoothly without folds or wrinkles.

C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than manufacturer's instructions.

E. Do not drag filter fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.

H. Do not leave fabric uncovered for more than 5 days.

I. Use 18 inch long piins to secure the fabric during installation.

3.04 FIELD QUALITY CONTROL

A. Inspection:
   1. Before covering, the condition of the fabric will be observed by the CONSTRUCTION MANAGER to determine that no holes or rips exist in the fabric.
   2. Repair all holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31 32 36

SOIL NAIL RETAINING WALLS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Permanent soil nail retaining walls, including design.
2. Monitoring and control of deformations of the soil nail wall, surrounding ground, utilities, and other facilities existing at the time of construction.
3. Verification and proof tests including load schedules, acceptance criteria, frequency of tests, and testing equipment.

B. Design Requirements:

1. Design the soil nail walls according to guidance provided in FHWA GEC 7.
    a. Provide a minimum design life of 75 years for soil nail walls and all components. Include supporting data and calculations in the design submittal.
    b. Provide corrosion protection as shown for SBSNs.
    c. Provide sacrificial steel corrosion protection according to FHWA GEC 7 for HBSNs.
    d. Do not use HBSNs in aggressive soils.
    e. Use a soil nail length of at least 10 ft.
    f. Design soil nail walls to withstand seismic ground shaking.
2. Provide a structural facing thickness of at least 10 inches excluding architectural relief.
    a. Provide reinforcement in the structural facing consisting of at least No. 4 bars at 12-inch spacing in both directions.
        1) Supplement this minimum reinforcing with additional bars or with wire mesh as required by the design and construction methods.
3. Extend facing at the toe of the wall to at least 2 ft below the finished grade at front face of wall at all points.
4. Provide expansion joints and contraction joints at appropriate intervals for the wall design, according to FHWA GEC 7.
5. Locate the top row of nails within 2 ft of the top of the wall.
6. Arrange soil nails so that the distance between the lowest row of soil nails and the facing at the toe of the wall is less than two thirds of the vertical nail spacing.
7. Consider the locations of existing utilities or obstructions in the area of construction.
8. Provide backwall drainage through weep holes or to toe drain as designed by Contractor in addition to drainage features shown on Contract Documents.
    a. Transmit backwall drainage between every column of soil nails down the wall through geocomposite strip drains.
    b. Provide a weep hole for each geocomposite strip drain.
    c. Provide a positive connection from each strip drain to a toe drain (where used), using a compatible drain connection grate and pipe.
9. Include provisions to prevent water flow over the top surface of the walls.

10. Show the quantity and locations of verification tests to be performed, accounting for subsurface conditions and variability, wall geometry, and project phasing.
    a. Require the greater of at least two verification tests per wall or one verification test per every 200 feet of wall.
    b. Size verification test nails so that the maximum test load does not exceed 90 percent of the minimum yield strength for Grade 75 through 80 bars and 80 percent of the minimum ultimate tensile strength for Grade 150 bars.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
APWA	Standard Specifications for Municipal Public Works Construction, Prepared by Utah State Chapter of the American Public Works Association
ASTM A 36	Standard Specification for Carbon Structural Steel
ASTM A 370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A 519	Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A 563	Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 706	Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
ASTM A 722	Standard Specification for High-Strength Steel Bars for Prestressed Concrete
ASTM A 767	Standard Specification for Zinc-Coated (Galvanized) Bars for Concrete Reinforcement
ASTM A 775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars
ASTM C 150	Standard Specification for Portland Cement
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM D 1621	Standard Test Method for Compressive Properties of Rigid Cellular Plastics
ASTM D 1785	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 3034	Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 4380	Standard Test Method for Determining Density of Construction Slurries
ASTM D 4716	Standard Test Methd for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

ASTM F 2648	Standard Specification for 2 in to 60 in Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Application
FHWA Geotechnical Engineering Circular No. 7	Soil Nail Walls Reference Manual, Report No. FHWA-NHI-14-007, February 2015 (FHWA GEC7)
OSHA	OSHA Safety Regulations (29 CFR, Part 1926, Subpart P Excavations)

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

1.03 DEFINITIONS

A. Bird's Beak: The space above the bottom elevation of the inclined drill hole opening at the face of the wall after grout placement.

B. Hollow Bar Soil Nail (HBSN): Hollow core and self-drilling bar advanced into the soil by drilling with a sacrificial bit as grout is injected through the bar.

C. Solid Bar Soil Nail (SBSN): Solid threaded bar installed into a drilled hole and grouted from the beginning at the bottom of the hole using a grout tube or tremie pipe.

1.04 SUBMITTALS

A. Soil Nail Contractor Qualifications for review. Include at least the following:

1. Company name.
2. List of planned subcontractors for design and construction.
3. List of the following personnel and their experience with at least three permanently anchored or nailed structures in the last three years:
    a. Drill operators.
    b. On-site supervisors assigned to the project.
4. Do not substitute for these personnel without authorization.

B. Wall Designer Qualifications for review when Contractor provides wall design. Include at least the following:

1. Wall Designer name and professional engineer licensing information.
2. Company name.
3. Do not substitute for the wall designer without authorization.

C. Soil Nail Retaining Wall Drawings for review. Include at least the following:

1. Plans, profiles, cross-sections, quantities, and details for each retaining wall.
    a. Subsurface exploration locations noted with station and offsets with respect to the wall alignment.

1) Provide soil data sheets for each subsurface exploration.

b. Top of wall detail.
   1) Aesthetically pleasing
   2) Adequately supports fence, drainage, or other requirements as shown.

c. Production soil nail details showing at least the following:
   1) Bar sizes and grades
   2) Corrosion protection
   3) Centralizers
   4) Nail head assemblies.

d. Verification test nail locations

e. Test nail details (verification and proof) including nail size, bonded/unbonded lengths, reaction frames and supports, jacks, load cells, and gauges.

f. Provisions for facilities directly behind the wall face, such as shoring elements, foundation elements, utilities, piping, and guardrail posts.

g. Surface and subsurface drainage details.

h. Architectural treatment details for wall facing elements and concrete color as shown.

i. Expansion/contraction joint locations and details.

2. Include supporting calculations sufficient to demonstrate that the soil nail walls are designed according to the required criteria.

3. Provide the seal of a Professional Engineer (PE) licensed in the State of Utah on the drawings and calculations.

D. Construction Plan for review. Include at least the following:

1. Wall construction start date and proposed detailed wall construction sequence and phasing plan.

2. Proposed methods to contain grout, shotcrete, and void-filling materials within the project area and Right-of-Way.

3. Proposed drilling methods, equipment, and drill hole diameters.

4. Proposed methods of soil nail installation.

5. Procedures for placing nail grout, grout quality control plan, and equipment.

6. Proposed methods for controlling seepage and unstable drill holes.

7. Monitoring and instrumentation plan. Include at least the following:
   a. Measures to verify wall and slope stability during construction.
   b. Details for measuring the movement of the excavated face and the wall during stability testing and construction.
   c. Methods, frequencies, and locations of measurement points for monitoring displacements of the wall facing, surrounding ground, utilities, and other existing facilities.

E. Equipment calibration data for information:

1. Calibration data for testing equipment including load cells, test jacks, pressure gages, and grout pumps.
   a. Include calibration date, device identification number, and calibration results, certified with an accuracy of at least 2 percent of the applied certification.

F. Manufacturer's product data sheets and installation instructions for furnished materials, for information, such as the following:

1. Soil nail bars
    a. Include ultimate strength and yield strength.
    b. Include corrosion protection, such as epoxy coating or encapsulation.
2. Bar couplers
3. Geocomposite strip drains.
4. Centralizers
5. Drain connection grates.

G. Nail grout mix design for approval, including:

1. Compressive strength test results, according to ASTM C 109, supplied by a qualified independent testing lab and verifying specified 3 day and 28-day minimum grout compressive strengths.
2. Include specific gravity test results of the fresh grout used for compression testing for neat cement grout.

H. Shotcrete mix design for approval, including:

1. Compressive strength test results, according to ASTM C 1604, supplied by a qualified independent testing lab and verifying specified 3 day and 28-day minimum compressive strengths.

I. Soil Nail Test Results for information within 48 hours of the test.

1. Include results from failed and passing soil nails.
2. Include at least the following:
    a. Project name, location, and type (verification or proof) of test.
        1) Include times and dates of drilling, installation, grouting, and testing.
    b. Name of person(s) performing testing.
    c. Hydraulic jack calibration information.
    d. Soil nail bar bonded and unbonded lengths, as well as any additional bar length used for testing.
    e. Soil nail bar type, diameter, cross-sectional area, and grade of steel.
    f. Drill method, hole length, and diameter.
    g. Maximum test load.
    h. Ultimate load capacity of soil nail bar.
    i. Soil to grout bond strength.
    j. Tabulated individual and average displacements for each dial gage at each specified loading increment and observation period.

J. Soil Nail Retaining Wall As-Built Drawings for information within 30 days after completion of the work.

1. Provide the locations and lengths of the nails for each wall. Include Northings, Eastings, elevation, azimuth, and inclination (to the nearest 0.1 inch and 0.5 degrees), Include survey datum.
2. Provide revised design calculations signed and sealed by a PE licensed in the State of Utah for design changes made during the construction of the wall.

1.05 AESTHETICS TEST PANELS

A. Construct a 3 ft high by 10 ft long test panel on-site for final shotcrete facings with sculpted or formed aesthetic treatments.
   1. Receive authorization before beginning production work.
   2. Use the same sculpting or forming methods, procedures, form liner, texture configuration, expansion joint, concrete mixture, and color/stain application proposed for the production work.
   3. Furnish one test panel for each type of wall finish.

1.06 QUALITY CONTROL

A. Soil Nail Grout
   1. Test each batch of grout for specific gravity using a mud balance according to the procedure in ASTM D 4380.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle materials in a manner that will prevent contamination, segregation, corrosion, and damage.
   1. Store and protect all bars such that corrosion protective coatings, bar surfaces, and threads are undamaged.
   2. Geocomposite strip drain
      a. Store/stockpile in a manner which protects the material from mud, dirt, dust, debris, and shotcrete rebound.
      b. Do not remove the protective wrapping until immediately before material is installed.
      c. Avoid exposure to ultraviolet light.

PART 2 PRODUCTS

2.01 SOIL NAILS

A. Soil Nail Tendon.
   1. Provide fully threaded solid or hollow bars as shown, continuous or with couplers, threaded to allow proper attachment of bearing plate, washer, and nut.
   2. Solid Bar Soil Nails (SBSNs)
      a. Use solid threaded bar according to one of the following:
         1) ASTM A 706 Grade 75 or 80
         2) ASTM A 722 Grade 150.
      b. Verify that bar meets the minimum capacity required at the threaded section if threads are cut into the bar.
   3. Hollow Bar Soil Nails (HBSNs), unless excluded as shown.
      a. ASTM A 519 Grade 75 or better, size as shown.
      b. Fully-threaded hollow-steel tubing that serves as drilling steel, grout transfer medium, and reinforcing element of the soil nail.

c. Uniform elongation without necking (Agt) greater than or equal to 5 percent.
d. Minimum Charpy impact resistance of 30 ft-lb at -4 degrees F (40 J at -20 degrees C) according to ASTM A 370.
e. Provide bar couplers with seals or similar mechanisms to verify minimum grout loss and a means of transferring percussive drilling forces, if required.
f. Select drill bits based on subsurface data and minimum grout column requirements, with at least two ports for grout exit.

4. Bar Couplers
   a. Develop the full nominal tensile capacity of the soil nail bar as certified by the manufacturer.
5. Corrosion protection
   a. SBSNs
      1) Bar encapsulation. Use one of the following sheathings:
         a) Corrugated high-density polyethylene (HDPE) tube having a minimum wall thickness of 60 mils and conforming to ASTM F 2648.
         b) Corrugated PVC tube having a minimum wall thickness of 40 mils.
      2) Bar coating. Use one of the following:
         a) Use epoxy-coated bars according to ASTM A 775 with between 0.008- and 0.012-inch coating thickness. Omit bend test requirements.
         b) Use galvanized bars according to ASTM A 767 with minimum coating thickness of 3.4 mil.

B. Centralizers
1. SBSNs.
   a. Use centralizers manufactured from Schedule 20 or 40 PVC pipe securely attached to the soil nail bar with coated wire.
   b. Size to position the soil nail bar within 1.0 inch of the center of the drill hole.
2. HBSNs.
   a. Centralizers are not required for HBSN.

C. Nail Head Assemblies
1. Bearing Plate Assembly
   a. Bearing Plate
      1) ASTM A36, Grade 36. Refer to Section 05120.
   b. Shear Connectors
      1) Headed studs or anchor bolts.
   c. Fabrication
      1) Refer to AASHTO/AWS D1.5.
   d. Galvanize after fabrication according to ASTM A 767.
2. Nuts and Washers
   a. ASTM A 563, hexagonal.
   b. Fit with beveled washers or spherical seats to provide uniform bearing.
   c. Galvanize according to ASTM A 767.

D. Soil Nail Grout

1. Use a neat cement or sand/cement mixture.
    a. Use either Type II Portland Cement meeting ASTM C 150 or Type IL cement meeting ASTM C 595.
    b. Use admixtures as appropriate to control bleed, improve flowability, reduce water content, and/or retard set, as specified in the authorized submittals.
        1) Use only admixtures that are compatible with the grout and mixed according to the manufacturer's recommendations.
        2) Do not use accelerators.
2. Meet 3-day minimum compressive strength of at least 2,000 psi according to ASTM C 109
3. Meet 28-day minimum compressive strength of at least 4,000 psi according to ASTM C 109
4. Meet specific gravity between 1.80 and 1.90.

2.02 FACING

A. Shotcrete
    1. Use a wet mix shotcrete.
        a. Use either Type II Portland Cement meeting ASTM C 150 or Type IL cement meeting ASTM C 595.
        b. Meet air content range of 8% to 10% at the pump.
        c. Meet 28-day minimum compressive strength of at least 4,000 psi.
        d. Use a curing compound that complies with ASTM C 309 Type 1-D or Type 2, Class A
    2. Owner will perform the following testing.
        a. Air Content per AASHTO T 152 with a frequency of 1 per load prior to placement.
        b. 28-day Compressive Strength per ASTM C 1604 with a frequency of 1 set per 50 cubic yards using production test panels.

B. Concrete
    1. Class 4000 (Underground application). Refer to Section 03 30 04.

C. Reinforcing Steel and Welded Wire Reinforcement
    1. Coated. Refer to Section 03 20 00.

2.03 GEOCOMPOSITE STRIP DRAIN

A. Use a strip drain consisting of a drainage core and an attached or encapsulating filtration geotextile meeting the following:
    1. At least 85 percent by mass of polypropylenes, polyester, polyamine, polyvinyl chloride, polyolefin, or polystyrene.
    2. Compressive strength of at least 40 psi when tested according to ASTM D 1621, Procedure A.
    3. Flow rate of at least 0.1 gallons per second per foot of strip width under a gradient of 1.0 tested according to ASTM D 4716.
    4. Provide in rolls wrapped with a protective covering and labeled to identify the production run.

2.04 TOE DRAIN

A. Perforated Pipe

1. ASTM D 1785 Schedule 40 PVC solid and perforated wall; cell classification 12454-B or 12454-C, wall thickness SDR 35, with solvent or elastomeric joints

B. Fittings

1. ASTM D 3034, cell classification 12454-B or 12454-C, wall thickness SDR-35, with solvent or elastomeric joints.

C. Type E: 1-1/2" Drain Rock

1. Refer to Section 31 23 00.

D. Drainage Geotextile

1. Refer to Section 31 05 19.

2.05 EXPANSION JOINT MATERIALS

A. Preformed Joint Filler

1. Refer to Section 32 13 73

B. Backer Rod

1. Refer to Section 32 13 73

C. Joint Sealant

1. Refer to Section 32 13 73

2.06 EQUIPMENT

A. Soil Nail Grouting

1. Use a high-shear colloidal mixer with separate holding tank and water and cement dosing system to verify continuous grouting independent from mixing.
2. Capable of grout pump flow rate of at least 15 gpm for bars less than 2-inch diameter and 45 gpm for bars 2 inch or greater in diameter.
3. Capable of grout pump pressure of at least 250 psi in sands/gravels and 1,500 psi in clays/silts.

B. Soil Nail Testing

1. Provide testing equipment including dial gages, dial gage support, jack and pressure gage, load cell, and a reaction frame as shown.
   a. Use a pressure gage with a maximum graduation of 50 psi and use calibrated load cell for load steps.
   b. Support dial gages on a frame that is independent from the jacking and the wall.
   c. Measure nail head movement with at least 2 dial gages capable of measuring to 0.001 inch.
2. Use testing equipment that has been calibrated by an independent testing lab within 90 days of the submittal date.
   a. Calibrate jack and pressure gage as a single unit.

PART 3 EXECUTION

3.01 GENERAL

A. Follow the authorized soil nail retaining wall drawings.

B. Perform additional exploration and testing when appropriate to complete final design.

3.02 EXCAVATION

A. Refer to Section 31 23 00.

B. Establish the ground contour above the wall to its final configuration and slope as shown before beginning excavation of the soil for the first row of soil nails.

C. Excavate from top down in staged horizontal lifts.

1. Limit the excavation to no more than 3 ft below the elevation at which the soil nails will be installed for the current lift.
2. Place reinforced initial shotcrete facing before the vertical cut becomes unstable, but no more than 24 hours after excavation.
    a. Place reinforcement with at least 2 inch of shotcrete cover between the soil or the strip drain, and the reinforcement.
3. Do not excavate a lift until the soil nail installation and reinforced initial shotcrete placement for the preceding lift is completed.

D. Excavated face.

1. Remove loose materials, mud, rebound, and other foreign matter that could prevent or reduce shotcrete bond before placing shotcrete.
2. Accuracy
    a. Sufficient to allow placement of the required shotcrete thickness shown.
        1) Additional shotcrete thickness due to overexcavation or irregularities in the excavated face is at no additional cost to the Owner.
    b. Sufficient to prevent damage to overlying shotcrete sections by undermining or other causes.

E. Monitor the wall and slope stability during construction.

1. Suspend soil nail wall construction if an excavation becomes unstable.
    a. Temporarily stabilize the excavation by immediately placing an earth berm against the unstable excavation face.
    b. Notify the Engineer immediately.

3.03 SOIL NAIL INSTALLATION

A. Drilling

1. Use core drilling, rotary drilling, percussion drilling, auger drilling, or driven casing.
    a. Use a method that prevents loss of ground above the drilled hole that may be detrimental to the soil nails or existing structures.
    b. Use a method that is suited to the ground conditions.

c. Use cased drilling methods or other suitable means to support the sides of the drill holes if needed.
    1) Remove casing unless Engineer permits it to remain.

2. Drilled hole tolerances.
    a. Inclination
        1) Within ±3 degrees of planned angle at the bearing plate
    b. Location
        1) Within ±0.5 ft of the planned location at the face of the excavated surface (point of entry).
    c. Horizontal Splaying
        1) Splay drill holes up to 10 degrees horizontally from plan orientation to avoid obstructions such as piles, drainage features, utilities, etc.
        2) Note location of splayed nails and reason for splay on as-built drawings.
3. Adjust drill hole and soil nail length as necessary to develop the load capacity and satisfy acceptance criteria for the required design load if required by testing.

B. Tendon Insertion

1. Inspect bar coating or encapsulation on soil nail bars before insertion into the drill hole.
    a. Replace soil nail bars exhibiting abrasions, cuts, welds, weld spatter, corrosion, or pitting.
    b. Replace or repair soil nail bars exhibiting damage to bar coating or to encapsulation.
2. Space centralizers no greater than 10 ft apart and no more than 1.5 ft from the end of each nail.
    a. Use centralizers that allow tremie pipe insertion to the bottom of the hole, and free flow of grout up the hole.
    b. Attach to the bar in front of the couplings for HBSNs.
3. Insert soil nail tendon into the drilled hole without difficulty.
    a. Remove the tendon and clean or redrill the drill hole to permit insertion if the tendon cannot be completely inserted.
    b. Do not drive or force partially inserted bars into the hole.
4. Notify the Engineer and the Wall Designer immediately if soil nails cannot be installed as shown.

C. Grouting

1. Grout the drill hole after installation of the soil nail bar and within 2 hours of completing drilling.
2. Inject grout at the lowest point of each drill hole through a hollow bar soil nail, grout tube, casing, hollow-stem auger, or drill rods.
3. Place the outlet end of the grout delivery tube below the surface of the grout as the conduit is withdrawn to prevent the creation of voids.
4. Fill the drill hole in one continuous operation. Do not allow cold joints in the grout column except at the top of the test-bond length of proof-tested production nails.
5. Consider hollow bar soil nails to be completed when the final grout returns to the excavated face, signaling that drilling spoils have been removed.

6. Provide at least 1 inch of grout cover between the soil nail bar and the surrounding soil for SBSN.
7. Fill bird's beaks with additional grout after placing a temporary cover in front of the drill hole. Alternatively, fill bird's beaks with shotcrete.
    a. Position shotcrete nozzle into the mouth of the drill-hole to completely fill the void where shotcrete is used to backfill bird's beaks.
8. Do not add water to grout conforming to the mix design to improve workability.

D. Nail Head Assembly

1. Attach a bearing plate, washers, and nut to each nail head as shown.
2. Provide uniform contact between the plate and the shotcrete.
    a. Seat the bearing plate uniformly on the shotcrete while the facing is still plastic and before its initial set. Hand-wrench tighten the nut.
    b. Set the bearing plate in a bed of grout if needed. Re-tighten the nut by hand with a wrench after the grout has set for 24 hours.

3.04 SHOTCRETE PLACEMENT

A. Prepare shotcrete application surface by:

1. Removing loose material, mud, rebound, and other foreign matter.
2. Clear any vegetation or organic material from the surface.
3. Remove curing compound on previously placed shotcrete surfaces by sandblasting.
4. Install depth gages on 4 ft centers longitudinally and vertically to indicate the thickness of shotcrete layers.
5. Dampen natural excavated surfaces immediately before shooting.

B. Place shotcrete in one or more layers.

1. Apply shotcrete within discharge time limit indicated in the approved mix design.
2. Make the surface of each shotcrete layer uniform and free of sags, drips, or runs.
3. Limit the layer thickness to 3 inches per application with no sloughing or sagging.
4. Remove laitance, loose material, and rebound.
    a. Promptly remove rebound from work area.
5. Do not apply shotcrete during adverse weather including rain, snow, and high winds without adequate protection.
    a. Cease placement operations when the ambient temperature drops below 50 degrees F.
6. Form construction joints by cutting plastic shotcrete and taper construction joints at an approximately 45-degree angle from the receiving surface.
7. Apply curing compound to shotcrete surfaces are exposed in their final condition.
8. Construct test panels for compressive strength testing using wood forms at least 3.5 inch thick by 2 feet by 2 feet in size.
    a. Do not include reinforcing steel bars in the test panels.
    b. Cure test panels in similar conditions to what is anticipated in the field and until test specimens are sampled.

3.05 SOIL NAIL TESTING

A. General

1. Conduct soil nail testing after the Wall Designer approves the calibration reports.
2. Perform soil nail testing after the nail grout and shotcrete facing have cured for at least 72 hours and have attained their specified 3-day compressive strength.
3. Do not apply loads greater than the following:
   a. Grade 75 or 80 bars: 90 percent of the minimum yield strength of the soil nail bar
   b. Grade 150 bars: 80 percent of the minimum ultimate tensile strength of the soil nail bar
4. Use verification and proof test nails having an unbonded length of at least 3 ft.
   a. Clean out the hollow bar unbonded length after bar installation.
   b. Do not place a PVC pipe bond breaker without cleanout as a substitute for providing the required unbonded length.
   c. Measure and verify void for unbonded length before testing.
5. Provide verification test and proof test nails having a bonded length of at least 10 ft. Shorter bonded lengths are appropriate for proof tests on production nails less than 13 feet in length.
6. Immediately report failed verification and proof nail test results to the Engineer and the Wall Designer, with the soil nail location, bonded and unbonded lengths, maximum load held, and the failure load.

B. Verification Testing

1. Perform verification tests on sacrificial nails at the locations shown.
   a. Perform additional verification testing as determined by the Engineer.
   b. Test nails of the same design and constructed with the same methods to be used on production nails.
2. Test sacrificial nails before installation of production soil nails to verify that the design nail pullout resistance is representative of the Contractor's drilling and installation methods in the site soils.
3. Notify the Engineer of changes to drilling methods, installation methods, or equipment during installation of production nails.
   a. Test additional sacrificial nails to address these changes as determined by the Engineer at no additional cost to the Owner.
4. Test soil nails with a known bonded length and a measured unbonded length.
5. Select a bonded length, L_{BVT}, as follows:
   a. Calculate L_{VBTmax}

$$L_{BVTmax} = (C_{RT} \times A_t \times f_s) / (r_{po}) \qquad \text{EQ1}$$

where:

C_{RT} = reduction coefficient; 0.9 for Grade 75 or 80 bar or 0.8 for Grade 150 bar

A_t = cross-sectional area of the test soil nail bar

r_{po} = nominal load transfer rate (kips/ft)
= $\pi \times q_u \times D_{dh} / 12$
q_u = bond strength (ksf)
D_{dh} = drill hole diameter (inch)
f_s = nominal resistance of the test tendon, f_y or f_u (ksi)

in which:

f_y = nominal yield resistance of the test tendon (ksi) for Grade 75 or 80 bar
f_u = minimum ultimate tensile strength of the test tendon (ksi) for Grade 150 bar

b. If $L_{VBTmax} > 10$ ft, $10 \text{ ft} \leq LVBT \leq L_{VBTmax}$
c. If $L_{VBTmax} < 10$ ft, LVBT = 10 ft, increase the test tendon size until $L_{VBTmax} \geq 10$ ft.
d. Use q_u as shown.
e. Calculate the maximum load during the verification test, defined as the Verification Test Load (VTL), as follows:

$$VTL = L_{BVT} \times r_{po} \text{ (kips/ft)} \qquad EQ2$$

where:

L_{BVT} = verification test nail bonded length (ft)

6. Perform verification test by incrementally loading the verification test nail to pullout or maximum test load (VTL) according to Table 1.

Table 1

Verification Test Schedule	
Load	Observation Period (minutes)[3]
AL[1]	Apply AL And set dial gauge to "zero"
0.13 VTL[2]	10 (record soil nail head movement at 1, 2, 5, 10)
0.25 VTL	10 (record soil nail head movement at 1, 2, 5, 10)
0.38 VTL	10 (record soil nail head movement at 1, 2, 5, 10)
0.50 VTL	10 (record soil nail head movement at 1, 2, 5, 10)
0.63 VTL	10 (record soil nail head movement at 1, 2, 5, 10)
0.75 VTL (Creep Test)	60 (record soil nail head movement at 1, 2, 5, 6, 10, 20, 30, 50 ,60)
0.88 VTL	10 (record movement at 10)
1.00 VTL	10 (record movement at 10)
AL	Reduce to AL And record permanent set

Tables Notes:

[1] Alignment Load (AL) ≤ 0.025 VTL (kips)

[2] Verification Test Load (VTL) = L_{BVT} x r_{po} (kips/ft)

[3] Measure soil nail head movement after each load increment has been achieved and at each indicated time step

7. Maintain the load during the creep test to within 2 percent of the intended load by using a load cell.
8. Re-pump jack as needed to maintain load during hold times.
9. Reduce loading to the AL and record the permanent set after applying VTL or other maximum test load.
10. Perform stepped unloading where determined or authorized by the Wall Designer.
    a. Perform between one and seven intermediate steps in stepped unloading.
    b. Hold each load step until the gage readings are stable.

C. Proof Testing

1. Perform proof testing on production soil nails.
    a. Test at least 5 percent of production soil nails.
    b. Test no fewer than one production nail per row on each soil nail wall.
        1) Distribute the locations of proof tests evenly across the vertical and horizontal extent of the wall face.
    c. Test the number of nails in each row sufficient to account for variability of soil and installation technique.
    d. Proof test at least 10 percent of production soil nails, with at least two proof tests per row on each soil nail wall where HBSNs are used without centralizers.
2. The Engineer will determine locations and number of proof tests before completing grout placement.
3. Perform proof tests on soil nails with a known bonded length and a measured temporary unbonded length.
4. Select a bonded length (LBPT) for the proof tests such that LBPT is 10 ft or L_{BPTmax}, whichever is smaller.
5. Select L_{BPTmax}

$$L_{BPTmax} = (C_{RT} \times A_t \times f_s) / (r_{po} \times 0.75) \quad \text{EQ3}$$

6. Allow for bond lengths less than 10 ft for production proof nails shorter than 13 ft.
7. Do not proof test fully grouted nails.
8. Calculate the maximum load for proof tests, defined as the Proof Test Load (PTL), as follows:

$$PTL = L_{BPT} \times r_{po} \text{ (kips/ft)} \times 0.75 \quad \text{EQ4}$$

9. Conduct proof tests by incrementally loading the proof test nail according to the test loading schedule in Table 2.

Table 2

Proof Test Schedule	
Load	Observation Period (minutes)[1]
AL[2]	1
0.17 PTL[3]	Record movement when it stabilizes
0.33 PTL	Record movement when it stabilizes
0.50 PTL	Record movement when it stabilizes
0.67 PTL	Record movement when it stabilizes
0.83 PTL	Record movement when it stabilizes
1.0 PTL (Creep Test)[4]	10 (record soil nail head movement at 1, 2, 5, 6, 10 minutes)
AL	1

Tables Notes:

Re-zero dial gages after the alignment load is applied.

Re-pump jack as needed to maintain load within 5 percent of the intended load during hold times.

[1] If the soils reinforced with nails are relatively susceptible to deformation or creep, hold each load increment for 10 minutes and record soil nail movement at 1, 2, 5, 6, and 10 minutes.

[2] Alignment load ≤ 0.025 PTL

[3] Proof Test Load (PTL) = L_{BPT} x r_{po} (kips/ft) x 0.75

[4] If soil nail movement measured between 1 and 10 minutes exceeds 0.04 inch, maintain PTL for 50 more minutes and record movements at 20, 30, 50, and 60 minutes. Record permanent soil movement.

3.06 SOIL NAIL LOAD TEST ACCEPTANCE CRITERIA

A. A verification-tested or proof-tested soil nail is acceptable if all of the following are met:

1. The soil nail resists the creep test load with less than 0.04 inch of movement between the 1 minute and 10-minute readings.
2. The soil nail resists the creep test load with less than 0.08 inch of movement between the 6 minute and 60-minute readings if the creep test load is maintained for 60 minutes.
3. The creep rate is linear or decreasing throughout the creep test observation period.
4. The total soil nail movement (ΔTL) measured at the maximum test load (VTL or PTL) exceeds 80 percent of the theoretical elastic elongation of the temporary unbonded length of the test nail, as calculated using Equation 5 (EQ5).

$$\Delta TL > 0.8 \times \text{Maximum Test Load} \times L_{UB} / (E \times A_t) \qquad \text{EQ5}$$

where:

ΔTL = Total soil nail movement measured at the maximum test load (PTL or VTL)

L_{UB} = Test nail unbonded length

E = Young's Modulus of steel (29,000 ksi)

5. Pullout does not occur before achieving the maximum test load (VTL or PTL).

a. Pullout is defined as the load at which attempts to further increase the test load increment results in continued test nail movement.

B. Verification-tested Nail Failure

1. Modify the design or the installation procedures or both.
2. Install replacement sacrificial nails for verification testing.

C. Proof-tested Nail Failure

1. The production nail will be rejected.
2. The Engineer may determine that additional proof testing is required to delineate the area of unsatisfactory production nails.
3. Evaluate and modify the design and construction procedures as applicable.

3.07 WALL DRAINAGE

A. Install and secure wall drainage elements.

1. Wall drainage elements include geocomposite strip drains, PVC connection pipes, soil nail wall toe drains, and weep holes.
2. Construct wall drainage to provide continuous and unrestricted flow to discharge water collected behind the wall face.
3. Install wall drainage elements before shotcreting with the exception of toe drains in front of the wall face.

B. Geocomposite strip drains.

1. Center between each column of soil nails, as shown.
2. Provide a minimum strip width of 12 inches.
3. Secure in continuous contact with the excavated face, and with the geotextile side against the excavated face.
4. Prevent shotcrete contamination of the geotextile against the excavated face.

C. Toe drains

1. Install at the bottom of the wall, according to the authorized soil nail retaining wall drawings.
2. Encase the free-draining granular backfill and pipe with drainage geotextile that conforms to the dimensions of the excavated trench.

3.08 FACING JOINTS

A. Construct expansion and contraction joints through the final shotcrete layer as shown.

3.09 CONSTRUCTION TOLERANCES

A. Refer to Table 3.

Table 3

Construction Tolerances	
Item	Tolerance

Cross-sectional location for reinforcing steel, welded wire reinforcement, and shear connectors.	3/8 inch
Location of headed studs on bearing plate	¼ inch
Reinforcing steel lap	1 inch
Planeness of finish surface, gap under 10-ft straight edge, if troweled or screeded	9/16 inch
Planeness of finish surface, gap under 10-ft straight edge, if left as shot	1 1/8 inch
Nail head bearing plate deviation from parallel to wall face	10 degrees

END OF SECTION

SECTION 31 41 00

SHEETING, SHORING AND BRACING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies requirements for sheeting, shoring, and bracing of trenches and excavations greater than 5 feet in depth.

B. Design Requirements:
   1. The Contractor shall design sheeting, shoring, and bracing in accordance with OSHA regulations and appropriate design standards.
   2. Horizontal strutting below the barrel of a pipe and the use of pipe as support are not acceptable.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
APWA	Standard Specifications for Municipal Public Works Construction, Prepared by Utah State Chapter of the American Public Works Association
OSHA	OSHA Safety Regulations (29 CFR, Part 1926, Subpart P Excavations)

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

1.03 SUBMITTALS

A. Submittals in accordance with General Conditions, Section 01 33 00 and Section 01 57 29, Integrated Excavation Plan.

B. Submit a Sheeting, Shoring, and Bracing Plan including: design calculations, shop drawings, and detail drawings that demonstrate conformity with OSHA regulations and suitability for design loads and installation methodology. The Design Plan shall be stamped and signed by a Registered Professional Engineer of the State of Utah.

C. Submit shop drawings showing dimensions, elevation, and structural details for each utilized excavation support system. Include on the drawings any required construction sequence, loading, testing, monitoring, and re-bracing/removal requirements. The design shall be stamped and signed by a Registered Professional Engineer of the State of Utah.

1.04 DESIGN REQUIREMENTS

A. Design excavation support systems to withstand earth pressures, hydrostatic pressures, bottom heave, equipment loads, applicable traffic and construction loads, and other surcharge loads to allow safe construction without movement or settlement of the ground and to prevent damage to or movement of adjacent structures, streets, and utilities. Design each member or support element with appropriate safety factors.
   1. Geotechnical data has been prepared for this project per the Supplementary Conditions.

B. Acceptable excavation support methods include the use of trench boxes, suitable moving support systems, steel sheet pilings, soldier piles and lagging, secant pile structures, structural steel wales and struts, liner plates, tieback anchors, and timber. If soldier piles are used, insert in predrilled holes. Horizontal strutting below the barrel of a pipe and the use of pipe as support are not acceptable.
   1. Due to the nature of the existing soils and proximity of adjacent infrastructure no vibratory or impact-type installation or removal methods are permitted. All sheets shall be inserted by hydraulic pushing, or other previously approved methods. Any resulting damage to existing structures from installation or removal procedures shall be the responsibility of the CONTRACTOR.
   2. Provide construction stage loadings for a staged removal of the support system that conforms to the pipe, structure placement, and indicated backfill.
   3. Compaction of foundation, bedding, haunching, and backfill shall extend to the undisturbed trench wall during staged removal of the support system.

1.05 QUALITY ASSURANCE

A. Provide surveys to monitor movements of critical facilities in accordance with the requirements of Section 31 09 00.

B. Excavation support systems shall be designed by a professional engineer registered in the State of Utah who has a minimum of 5 years of experience in the design of retaining structures.

PART 2 PRODUCTS

A. Slide rail shoring may be required to protect existing buildings and utilities. Acceptable slide rail shoring suppliers include the following, or equal:
   1. GME (Griswold Machine and Engineering)
   2. Pro-Tec Equipment, Inc
   3. Efficiency Production, Inc..
   4. SHB, Double Slide Rail, Series 750.

B. Structural Steel: ASTM A36 or better, unless otherwise approved.

PART 3 EXECUTION

3.01 GENERAL

A. Provide, place, and maintain supports, shoring, and sheeting as may be required for sides of excavations. Slope or otherwise support excavations in a safe manner in accordance with applicable regulatory safety requirements.

B. The construction of sheeting, shoring, and bracing shall not disturb the state of soil adjacent to the trench and below the excavation bottom.

C. Trench sheeting below the top of a pipe shall be left in place.

D. All shoring shall be removed.

E. Provide, place, and maintain supports, shoring, and sheeting as may be required for sides of excavations. Support excavations in a safe manner in accordance with applicable regulatory safety requirements.

F. All welding will conform to the applicable provisions of ANSI/AWS D1.1.

3.02 SEQUENCE

A. Excavation shall not be started until the design for support has been accepted by the Owner.

3.03 TRENCHES

A. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable local construction safety orders, and OSHA requirements.

B. At any time Contractor's personnel are not present within the immediate vicinity of the Work, open excavations shall be plated, barricaded, or fenced, as necessary, to protect the public and worker safety.

3.04 REMOVAL OF SUPPORT SYSTEM

A. Excavation support shall not be removed until support can be removed without damage to existing facilities, completed Work, or adjacent property.

B. Any void left by shoring system or voids created by the removal of the shoring system shall be filled with controlled low strength material (CLSM) or cement grout, as approved by the Construction Manager.

END OF SECTION

SECTION 31 41 01

VIBRATION CONTROL

PART 1 GENERAL

1.01 SCOPE

A. This Section specifies procedures for monitoring and controlling vibrations adjacent to the project site that arise from installation of sheet piling, pile driving, soil compaction and other vibration-producing activities. The CONTRACTOR shall provide all necessary labor, equipment, materials, and services.

1.02 SUBMITTALS

A. Submittals in accordance with the General Conditions, Section 01 33 00 and Section 01 57 29, Integrated Excavation plan.

B. Seismograph Location Plan for review that includes proposed monitoring locations and existing structures and utilities that are to be protected. Vibration monitoring points (VMP) should be located at least four (4) feet from existing structures to reduce reflected vibrations.

1. A minimum of four VMP shall be provided by the Vibration Monitoring Specialist.

C. Calibration data and machine documentation for each seismograph used on the project.

1.03 QUALITY CONTROL

A. CONTRACTOR shall pay the costs for any re-testing or additional testing of Work not conforming to the Specifications. CONTRACTOR shall bring Work into compliance before Work will be accepted by CONSTRUCTION MANAGER.

1.04 DEFINITIONS

A. Vibration Monitoring Specialist: An individual experienced in vibration monitoring techniques for similar civil and geotechnical works, the preparation of vibration monitoring plans, instrumentation, and interpretation and use of vibration records. The Vibration Monitoring Specialist will possess all required federal, state and local licenses and/or permits. The Vibration Monitoring Specialist will be responsible for supervision of all field vibration monitoring operations and personnel and have a minimum 10 years of vibration monitoring experience.

PART 2 MATERIALS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Control and monitor vibrations when engaging in construction-related activity near objects, structures or utilities which may be susceptible to damage from ground vibrations.

3.02 EQUIPMENT

A. Use approved seismographs located, at a minimum and as approved by the ENGINEER, between the vibration source and the closest susceptible object(s), structure(s) or utility(ies).

B. Use seismographs capable of recording particle velocity for three (3) mutually perpendicular components of vibration.

C. Furnish records of seismograph characteristics and factory calibration to the ENGINEER prior to commencing vibration producing activity.

D. Provide vibration monitoring equipment capable of detecting velocities of 0.01 in/s or less that has been calibrated within the last year.

E. Use seismographs with response characteristics in the range generally found for the specific construction related activity being monitored.

3.03 MONITORING

A. Do not allow ground motions, in each component, to exceed the safe limits prescribed in paragraph E.

B. Use appropriate care in all vibration inducing operations. Repair, at no expense to the OWNER, any damage to neighboring structures or utilities caused by construction related vibrations.

C. Monitor every vibration-inducing activity for which ground motions may exceed 0.09 in/sec. at any structure or utility, using calibrated seismographs containing internal calibration and triaxial orthogonal transducers with a flat frequency response from 2 to 200 hz. Furnish real-time, permanent time histories of the vibration measurements in terms of particle velocity. Make vibration monitoring records available to the ENGINEER no later than 48 hours after measurements are taken.

D. Place transducers in locations approved by the ENGINEER. The ENGINEER may direct that different features be monitored.

E. Vibration limits are based on instrumentation with a flat frequency response from 2 to 200 hertz. Do not exceed the following maximum ground motions:
   1. 0.2 in/sec for steady state vibrations (vibrations generated by construction traffic, vibrating rollers, etc.).
   2. 0.1 in/sec for steady state vibrations at the existing utilities and buildings (vibrations generated by construction traffic, vibrating rollers, etc.).

END OF SECTION

C. As directed by the CONSTRUCTION MANAGER or when maximum allowable movement limits are exceeded per Table 2, immediately take additional readings to verify SMP, VMP, crack monitors, or inclinometer stability. Notify CONSTRUCTION MANAGER and submit readings.

D. Corrective Action Trigger Levels:

Table 2: Maximum Allowable Readings

Movement	Action Trigger Level	Maximum Allowable Movement
Movement	Action Trigger Level	Maximum Allowable Movement
SMP (vertical)	0.031 ft (0.375 in)	0.063 ft (0.75 in)
SMP (horizontal)	0.031 ft (0.375 in)	0.063 ft (0.75 in)
SMP (Differential)[A]		3/16“ (0.1875 in) over 15 ft
VMP[B]	0.5 in/sec	1.0 in/sec
Inclinometer	0.1 inch per days	1 inch
Crack Monitor	0.0052 ft (0.0625in)	0.0078 ft (0.09375 in)

A – Differential settlement measured on Buildings and Structures between SMPs (Vertical and Horizontal)

B - See Section 31 41 01 Vibration Control 3.03E

E. At any time during the Work, additional monitoring shall be performed if measurements fail to meet required accuracies, measurements detect significant, anomalous, or sudden changes in elevation or horizontal location and/or when action limits and maximum allowable movements are exceeded. Such additional monitoring will be performed at no additional cost to the OWNER.

F. Evaluate existing damage to properties in the area of influence of the construction project that might be affected by the construction activities.

3.06 PROTECTION, MAINTENANCE AND REPLACEMENT

A. Maintain access to SMP, VMP, crack monitors, and inclinometers throughout the duration of monitoring and performance of the Work.

B. Replace damaged or missing SMP, VMP, crack monitors and inclinometers immediately and notify the CONSTRUCTION MANAGER.

3.07 CLOSE-OUT READINGS

A. Upon completion of the Work, including backfill, grouting, and surface restoration, perform a minimum of two sets of monitoring readings of all SMP, crack monitors and inclinometers. Final Readings shall be performed seven (7) days and three (3) months after completion of the Work Submit the readings to the CONSTRUCTION MANAGER.

END OF SECTION

SECTION 32 12 16

ASPHALT PAVING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies paving consisting of aggregate base, asphaltic concrete, and associated materials.

1.02 DEFINITIONS

A. Bituminous prime coat: Consist of application of hot bituminous material on previously prepared base course.

PART 2 QUALITY ASSURANCE

2.01 REFERENCES

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D1557	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5-kg) Rammer and 18-in (457-mm) Drop
AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing	MP1: Specification for Performance Graded Asphalt Binder
ASTM C 117	Standard Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
ASTM C 131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 977	Standard Specification for Emulsified Asphalt.

Reference	Title
ASTM D 2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

B. Testing:
   1. Testing will be conducted by the Construction Manager to determine compliance with the specified degree of compaction and moisture content.

2.02 SUBMITTALS

A. Proposed mix design and gradation of materials.

B. Quality control submittals:
   1. Certificate of Compliance.

2.03 DELIVERY, STORAGE, AND HANDLING

A. Asphalt concrete delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.
   4. Transfer the mixture directly from the transport vehicle to the paving machine. Dumping asphalt on the ground and “shuttling” it to the paver will not be allowed.

PART 3 PRODUCTS

3.01 MATERIALS

A. Prime coat: Use bituminous material for prime coat conforming to requirements for MC 70 and apply at temperature of 105 to 175 degrees Fahrenheit at rate of 0.3 to

B. 0.6 gallons per square yard by use of bituminous distributor.

C. Sand: Acceptable to the ENGINEER.

D. Tack coat: Grade CSS-1h asphalt emulsion in accordance with ASTM D 977.

E. Asphalt concrete materials:
   1. Asphalt cement: Conform to requirements for asphalt cement, PG 64-28 AASHTO MP1.
   2. Mineral aggregate:
      a. Consist of coarse aggregate of crushed stone or gravel composed of hard, durable particles, sand, and filler as follows:
         1) Coarse aggregate: Portion of material retained on Number 8 sieve.
         2) Fine aggregate: That portion passing Number 8 sieve.

b. Provide composite material that is uniformly graded from coarse to fine and that complies with requirements of one of following gradings when tested in accordance with ASTM C 136.

c. Asphalt concrete: As indicated on the Drawings, 2 course mix for asphalt concrete having an overall thickness of 2 1/2 inches or more if not indicated. If less than 2 1/2 inches asphalt concrete, use single course mix.

Two Course Mix				Single Course Mix	
Seal, 2 inch Thick Minimum		Base, 2 inch Thick Minimum		1-1/2 inch Thick Minimum	
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
1/2"	100	1-1/4"	100	3/4"	100
3/8"	95 - 100	1"	87 - 100	1/2"	75 - 95
No. 4	60 - 80	3/4"	75 - 100	3/8"	65 - 85
No. 8	35 - 55	3/8"	55 - 80	No. 4	50 - 65
No. 30	15 - 30	No. 4	40 - 70	No. 8	35 - 50
No. 100	5 - 15	No. 8	30 - 50	No. 30	15 - 30
No. 200	3 - 7	No. 30	15 - 30	No. 100	5 - 15
		No. 100	5 - 15	No. 200	3 - 7
		No. 200	3 - 5		

3. Coarse aggregate:
   a. Consist of at least 70 percent by weight of each size aggregate and consist of particles, which have at least 1 rough, angular surface produced by crushing:
      1) Have percentage of wear of not more than 50 at 500 revolutions, in accordance with ASTM C 131.
   b. Aggregate plasticity index: Not more than 2 in accordance with ASTM D 4318.
   c. Sand may be added to crusher or pit run product to supply any deficiency in 8-mesh size, and filler may be added to supply any deficiency in 200-mesh material. If aggregate contains an excess of sand, wasting will be required.
   d. Filler:
      1) Use finely powdered limestones, portland cement, or other artificially or naturally powdered mineral dust, acceptable to the ENGINEER.
      2) Weigh filler and add separately to each batch at time of proportioning.
      3) Use filler that is free from deleterious matter of any kind.
      4) Fineness that meet the following requirements:
         a) Passing 50 mesh sieve: 100 percent.
         b) Passing 200 mesh sieve: At least 75 percent.
      5) Determine amount of material passing the Number 200 sieve in accordance with ASTM C 117.

e. Provide composite aggregate that is free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter which would prevent thorough coating of asphalt cement.

f. Materials derived from processing demolished, or removed asphalt concrete, are limited to 15%. RAP shall meet the same gradation requirements as the mineral aggregate.

F. Fog sealing: Asphalt emulsion, Grade CSS-1h.

G. Seal Coat: Maxwell products or equal.

H. Slurry Seal: UDOT Spec 02789.

3.02 EQUIPMENT

A. Bituminous distributor: Designed and equipped so as to distribute bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rate with pressure range of 25 to 75 pounds per square inch.

B. Liquid asphalt distributor:
   1. Designed and operated to distribute asphaltic material in uniform spray without atomization.
   2. Equipped with bitumeter having dial registering feet of travel per minute.
      a. Locate dial so that it is visible to truck driver so that he can maintain constant speed required for application at specified rate.
   3. Equip pump with tachometer having dial registering gallons per minute passing through nozzles.
      a. Locate dial so that it is readily visible to operator.
   4. Provide means for accurately indicating temperature of asphaltic material in distributor at all times.
      a. Locate thermometer well so that it is not in contact with, or close to, heating tube.
   5. Have spray bar having normal width of application of not less than 12 feet and capable of providing for application of lesser width when necessary.
   6. Provided with hose and spray nozzle attachment for applying asphaltic material to patches and areas inaccessible to spray bar.
   7. Equipped with heating attachments and capable of circulating asphaltic material through spray bar during entire heating process.

C. Asphalt concrete mixing plants:
   1. Equipment:
      a. Use screen and storage bins at plant of sufficient capacity to furnish the necessary amount of all aggregates, when operating at the maximum capacity of the plant, with no periods of undue waiting for material.
         1) Use bins consisting of at least 2 compartments, so proportioned as to insure adequate storage of appropriate fractions of the aggregate.
         2) Provide each compartment with an overflow pipe of such size and at such location as to prevent any backing up of material into other compartments.

b. Dryer:
    1) Designed to heat and dry the aggregate to Specification requirements and to agitate it continuously during the heating.
    2) Capable of preparing aggregates at a rate equal to the full-rated capacity of the plant.
c. Dust collector:
    1) So constructed as to waste or return uniformly to the hot elevator all or any part of the material collected.
d. Mixer:
    1) Adequate capacity, with twin shafts.
e. Thermometers:
    1) Furnished for determining the temperature of the mix.
f. Weighting and measuring equipment:
    1) Weighing or volumetric measuring equipment of sufficient capacity.
    2) Devices to permit easy readjustment of any working part needing readjustment, so that the equipment will function properly and accurately.
    3) Attach scales for weighing to the bucket.
    4) Test and seal all weighing equipment by a representative of the Inspector of Weights and Measures having jurisdiction, as often as the ENGINEER may deem necessary to insure accuracy.
g. Tanks for storage of bituminous material:
    1) Capable of heating the material under effective and positive control at all times to temperatures within the range stipulated.

2. Asphalt concrete plant operation:
    a. Mineral aggregate:
        1) Dry and heat mineral and then screen into at least 2 fractions and conveyed into separate compartments ready for proportioning and mixing.
        2) When combined with asphalt cement:
    b. Aggregate:
        1) Contain not more than 2 percent moisture by weight.
        2) Be at a temperature within the range of that specified for the asphalt cement but not more than 25 degrees Fahrenheit above the temperature of the asphalt cement.
    c. Combine dry aggregate in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified grading.
        1) Introduce the asphalt cement into the mixer in the amount and at the temperature for the particular material being used.
        2) Continue mixing for at least 30 seconds, and for such longer period as may be necessary to coat all the particles.
    d. When a continuous mixer is used, determine the mixing time by weight method using the following formula:
        1) Mixing time in seconds = Pugmill dead capacity in pounds.
        2) Pugmill output in pounds per second.

D. Asphalt concrete placing equipment:
   1. Use equipment for placing, spreading, shaping, and finishing asphalt concrete consisting of a self-contained power machine operating in such manner that no supplemental spreading, shaping, or finishing is required to provide surface which complies with requirements for smoothness contained in this Section.
      a. In areas inaccessible to the machine, hand spreading may be permitted.
   2. Furnish 1 self-propelled, pneumatic-tired roller, and one 8 ton (minimum), smooth-wheel tandem roller.
      a. When spreading is in excess of 100 tons per hour, furnish 1 additional roller of either type for each additional 100 tons, or fraction thereof, spread per hour.

3.03 MIXES

A. Asphalt cement:
   1. Do not mix at temperatures lower than 275 degrees Fahrenheit nor higher than 325 degrees Fahrenheit.
   2. Amount of asphalt cement, by weight, to be added to aggregate shall be at least 5.4 percent of weight of mixture.
   3. Voids filled with asphalt (VFA), %: 70 - 80
   4. Voids in mineral aggregate (VMA), %:
      a. 13.5% - 14.5% for 3/4-inch
      b. 14.5% - 15.5% for 1/2-inch
   5. Dust proportion range: 0.6 - 1.40
   6. Air voids, %: 3.5 - 4.5

B. Asphalt concrete:
   1. Before being delivered to the site, mix aggregate with asphalt cement at central mixing plant.
   2. Use mixing plants that are in good working order with no excessively worn parts and so equipped that:
      a. Temperatures of aggregates leaving dryer, of asphalt cement entering mixer, and of mix leaving mixer can be readily determined and positively controlled within Specification limits at all times.
      b. Weights of different sizes of aggregates and of asphalt cement as set by the ENGINEER can be consistently introduced into mixer.
      c. Asphalt cement can be uniformly distributed throughout mixture with aggregate completely coated.
      d. Mixing time can be positively controlled to minimum specified.
      e. Bin samples of aggregate can be readily obtained.
      f. Provide means of calibrating weighing devices.

PART 4 EXECUTION

4.01 PREPARATION

A. Protection
   1. Prime coated surfaces:
      a. Maintain surfaces until succeeding layer of pavement has been placed.
      b. During this interval, protect primed surfaces against damage and repair any broken spots.
      c. Protect all structures from being spattered or marred by overspray or applicator.

B. Surface preparation:
   1. Prime coat:
      a. Where portions of base course prepared for immediate treatment are excessively dry, sprinkle such portions lightly with water immediately in advance of prime coat application.
      b. Immediately following preparation of base course, apply bituminous material by means of bituminous distributor at the temperature previously specified.
      c. Apply priming material in manner that results in uniform distribution being obtained at all points of surface to be primed.
      d. Following the application of prime material, allow the surface to dry for a period of not less than 48 hours without being disturbed, or for such additional period of time as may be necessary to obtain penetration into the base course and drying out or evaporation of the volatiles from prime material.
      e. Spread sufficient sand on areas which show an excess of bituminous material to effectively blot up and cure the excess.
   2. Base courses:
      a. Thoroughly clean base and apply prime coat before placing asphalt concrete.
      b. Thoroughly clean any existing base, surfacing, or pavement prior to placing plant-mixed surfacing.
      c. Where existing pavement is being widened or extended cut to straight vertical face and treat with asphalt paint binder prior to paving operations.
      d. When asphalt concrete is to be applied over existing pavement and local irregularities in existing surface would result in course of more than specified thickness, bring surface of existing pavement to uniform contour by patching with asphalt concrete thoroughly tamped or rolled until it conforms with surrounding surface, and then apply tack coat.

4.02 APPLICATION

A. Tack Coat:
   1. At existing asphalt to be paved over and at all vertical faces of concrete or asphalt: Apply tack coat at minimum rate of 0.10 gallons per square yard.
   2. Clean the surface of all materials that prevent the tack coat from bonding to the existing surface such as mud, dirt, leaves, etc.
   3. Protect all structures from being spattered or marred by overspray or applicator.

B. Placing and compacting asphalt concrete:
   1. Placing and compacting asphalt mixture: Progress in sections generally not more than 250 linear feet in length.
   2. Spreading of mixture:
      a. Spread, shape, and finish by specified equipment.
      b. Spread each successive strip adjacent to previously spread strip.
      c. Do not compact minimum 6-inch width of each strip adjacent to new strip until after new strip has been placed.
      d. Spread as nearly continuous as possible.
      e. Laying against vertical surfaces such as gutters: Roughen and clean face of vertical surfaces as required for proper bonding and then paint with light coating of asphalt cement or emulsified asphalt.
      f. At terminations of new surface courses: Feather asphalt mixture into existing surface over such distance as may be required to produce smooth riding transition.
      g. Base course and single course construction: Joined by vertical butt joints, finished and rolled to smooth surface.
      h. Rolling:
         1) Perform initial or "breakdown" rolling with tandem power roller and follow spreading operation when mixture has reached temperature where it does not "pick up" on rolls.
         2) Keep rolls properly moistened but do not use surplus of water.
         3) Follow initial rolling with pneumatic roller when mixture is in proper condition and when rolling does not cause undue displacement, cracking, or shoving.
         4) Begin rolling at sides and progress gradually to center, lapping each preceding track until entire surface has been rolled.
         5) Terminate alternate trips of roller in stops at least three feet distant from any preceding stop.
         6) At any place not accessible to roller, thoroughly compact mixture with tampers and finish, if necessary, with hot iron to provide uniform layer over entire width being paved.
   3. Offset longitudinal joints 6 to 12 inches in succeeding courses.
      a. Tack the longitudinal edge before placing the adjacent pass if the previous pass has cooled below 175 degrees F.
   4. Provide finish surface having uniform texture and sealed surface.

C. Slurry sealing:
   1. Slurry seal asphalt pavement after compaction with slurry sealing material applied at rate of 18-22 lbs. per square yard at following locations:
      a. All asphalt pavement.

D. Full-depth asphalt pavement:
   1. CONTRACTOR's option:
      a. Not permitted to use one system in one location and another system elsewhere.

b. Install either asphalt and aggregate base material or full-depth asphalt pavement in areas where paving is indicated on the Drawings or specified to be 2 inches of asphalt concrete over aggregate base course.

c. If option is selected to install full-depth asphalt pavement, prepare subgrade as previously specified in this Section.

d. Substitute asphalt concrete for aggregate base at ratio of 1 inch of asphalt concrete to 2-1/2 inches of aggregate base material. Use full-depth asphalt pavement not less than 4 inches in thickness after compaction.

e. Place asphalt concrete in courses of not more than 4 inches.

f. Use compaction equipment in accordance with following course thicknesses:

1) 1 to 2 inch thickness: Minimum 8 ton roller.

2) 2 to 3 inch thickness: Minimum 10 ton roller.

3) 3 to 4 inch thickness: Minimum 12 ton roller.

2. Pneumatic rollers used for initial or secondary rolling: Use 12 to 15 tons with tires capable of 90 pounds per square inch inflation pressure.

3. Asphalt concrete for full-depth asphalt pavement:

a. Asphalt concrete as previously specified in this Section

b. Apply bituminous prime coats where full-depth asphalt pavement is installed.

c. CONTRACTOR's option: If CONTRACTOR elects to use full-depth asphalt pavement, at road shoulders reduce aggregate base course to minimum aggregate thickness of 4 inches.

4. Except for asphalt thickness, aggregate base course thickness and prime coating, full-depth asphalt pavement comply with requirements of this Section.

4.03 FIELD QUALITY CONTROL

A. Placement:

1. Place the mixture on the roads, pavements, or walks at a temperature not less than 225 degrees Fahrenheit.

B. Tests:

1. Provide sampling and control testing for the asphalt concrete.

a. The type and size of the samples: Suitable to determine conformance with stability, density, thickness, compaction, and other specified requirements.

b. Use an approved power saw or core drill for cutting samples.

c. Furnish all tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.

d. Take a minimum 1 sample per 200 tons of asphalt concrete placed.

C. Inspection:

1. Asphalt concrete:

a. Test with a 10-foot straightedge laid on the surface parallel with the centerline of the road: Variation of the surface from the testing edge of the straightedge not to exceed 1/4 inch.

END OF SECTION

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SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies galvanized chain link fence comprising fences, gates, and appurtenances.

B. Related Sections:
   1. Section 32 31 15 Hydraulic Vertical Pivot Gate System
   2. Division 3: Concrete support slab.
   3. Division 26: Electrical connections.

1.02 QUALITY ASSURANCE

A. Factory Testing:
   1. Wire fabric and barbed wire shall be tested for zinc coating weight by the method specified in ASTM A90. Ferrous metal, except the fabric, shall be tested for zinc coating uniformity by the method specified in ASTM A239; zinc coating shall withstand six 1-minute dips.

B. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A90	Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
ASTM A53	Pipe, Steel, Black and Hot-Dipped Zinc-Coated, Welded and Seamless
ASTM A121	Zinc-Coated (Galvanized) Steel Barbed Wire
ASTM A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Zinc Coating (Hot Dip) on Iron and Steel Hardware
ASTM A239	Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulfate Dip)

Reference	Title
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes.
ASTM F1184	Industrial & Commercial Horizontal Slide Gates
ASTM A392	Zinc-Coated Steel Chain-Link Fence Fabric

1.03 SUBMITTALS

A. Shop Drawings: Detailed information and specifications for materials, finishes, gate operators, gate elevations, and dimensions. Show location of gate systems in relationship with adjacent fencing and paving, details of installation, hardware locations, and accessories. Provide drawings or templates for installation of anchor bolts in support slab.

B. Wiring Diagrams: Furnish manufacturer's wiring diagrams for gate operator.

C. Product Data: Furnish manufacturer's literature, operator manual, and parts manual for gate and operator and each manufactured accessory to be provided for project.

D. Samples: Approximately 6 inches square, or 6 inches long of posts, rails, braces, fabric, wire, ties, and fittings.

E. Quality Control Submittals:
   1. Manufacturer's recommended installation instructions.
   2. Evidence of Supplier and installer qualifications.
   3. Furnish manufacturer's certification indicating system provided complies with specified requirements.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Provide steel fence materials commercial grade with black powder-coated steel. All materials to match style, finish, and color of each fence component with that of other fence components.

B. VERTICAL LIFT GATE
   1. See 32 31 15 Hydraulic Vertical Pivot Gate System.
   2. Vertical Pivot Gate System: Ideal Mfg., Inc. /TILT-A-WAY Model HYJ

2.02 CHAIN LINK FENCE FABRIC

A. PVC-coated galvanized fabric conforming to ASTM F668, Class 1 or 29. PVC coating only applies where it is specifically indicated on the Drawings.
   1. Color: Black.
   2. Manufacturers and Products:
      a. Colorbond Corp., Raritan, NJ; Colorbond II.
      b. Cyclone Fence, United States Steel, Chicago, IL; Cyclone Color Fence System.

B. Height: 72 inches, unless otherwise shown.

C. Wire Gauge: No. 9.

D. Pattern: 2-inch diamond-mesh.

E. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.

F. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

G. Wires of Twisted Selvages:
   1. Twisted in a closed helix three full turns.
   2. Cut at an angle to provide sharp barbs that extend minimum 1/4-inch beyond twist.

H. Privacy Slats, if called for on Drawings:
   1. HDPE or PVC Top Lock slats sized for No. 9 gauge 2-inch mesh, approximately 1 3/32-inches wide.
   2. Length to match the fabric height minus 2 inches.
   3. Color selected by OWNER.

2.03 FENCE POSTS

A. General:
   1. Strength and Stiffness Requirements: ASTM F669, Heavy Industrial Fence, except as modified in this section.
   2. Steel Pipe: ASTM F1083.
   3. Roll-Formed Steel Shapes: Roll-formed from ASTM A570, Grade 45, steel.
   4. Protective Coatings:
      a. Zinc Coating: ASTM F1234, Type A external and internal coating.
   5. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

B. Line Posts:
   1. Steel Pipe:
      a. Outside Diameter: 2.375-inch.
      b. Weight: 3.65 pounds per foot.
   2. Roll-Formed Steel C Shape:
      a. Outside Dimensions: 2.25-inch by 1.625-inch.
      b. Weight: 2.70 pounds per foot.
   3. Steel H-Section:
      a. Outside Dimensions: 2.25-inch by 1.70-inch.
      b. Weight: 3.26 pounds per foot.

C. End, Corner, Angle, and Pull Posts:
   1. Steel Pipe:
      a. Outside Diameter: 2.875-inch.
      b. Weight: 5.79 pounds per foot.

D. Posts for Removable Fence Panels: As specified for end, corner, angle, and pull posts.

2.04 TOP RAILS AND BRACE RAILS

A. Galvanized steel pipe or roll-formed steel C shapes, color-coated.

B. Protective Coatings: As specified for posts.

C. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

D. Strength and Stiffness Requirements: ASTM F669, Top Rail, Heavy or Light Industrial Fence.

E. Steel Pipe:
   1. ASTM F1083.
   2. Outside Diameter: 1.625-inch.
   3. Weight: 2.27 pounds per foot.

F. Roll-Formed Steel C Shapes:
   1. Roll formed from ASTM A570, Grade 45.
   2. Outside Dimensions: 1.625-inch by 1.25-inch.
   3. Weight: 1.40 pounds per foot.

2.05 FENCE FITTINGS

A. General: In conformance with ASTM F626, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension and Brace Bands: No exceptions to ASTM F626.

D. Tension Bars:
   1. One-piece.
   2. Equal in length to full height of fabric.

E. Truss Rod Assembly: 3/8-inch diameter.

F. Barb Arms: 45-degree arms for supporting three strands of barbed wire.

2.06 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824, Type II, Class 2.

2.07 TRUSS RODS AND MISCELLANEOUS FITTINGS:

1. Truss rods shall be fabricated of 3/8-inch diameter steel rods and shall have turnbuckles or similar means of adjustment. Extension arms for barbed wire shall be steel or malleable iron. Gate hinges, drop bar locking devices, caps, gate stops and miscellaneous bolts, bands, and other appurtenances shall be consistent in quality and strength to the rest of the fence. Fittings used shall be hot-dip galvanized iron or steel with a minimum coating of at least 2.0 ounces of zinc per square foot of surface in accordance with ASTM A123 or A153, whichever is applicable.

2.08 CONCRETE:

1. Concrete for post foundations shall be as specified Type C-1 in Section 03 30 00.

2.09 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's product information designating specific materials provided.
   2. Results of the factory testing specified in paragraph 1.02 Factory Testing.
   3. The layout of the chain link fence as it is to be provided illustrating fence height, post sizes, bracing configurations, and accessories.

PART 3 EXECUTION

3.01 GENERAL

A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by ENGINEER. Erect fencing in straight lines between angle points.

B. Provide all necessary hardware for a complete fence and gate installation.

3.02 FENCE

A. Line posts shall be equally spaced between corners, end posts, and gate posts at a spacing not exceeding 10 feet. The base top shall be at least 1 inch above grade and sloped for drainage. Posts shall be set vertical, shall be accurately aligned, and shall have their tops level or at a constant slope between changes in grade. Tubular posts shall be fitted with extension arms for barbed wire, post top to permit passage of top rail or rainproof malleable iron caps as applicable.

B. Corner, end, and gate posts shall be braced to the nearest line post. Corner and end posts shall be diagonally braced. Bracing for gate posts shall be horizontal braces with truss rods. Line posts shall be braced horizontally and trussed in both directions with truss rods at 1000-foot minimum intervals. Top rails, where specified, shall be in lengths not less than 18 feet and shall be fitted with couplings for connecting lengths into continuous runs. Couplings shall be not less than 6 inches long and allow for expansion and contraction of the rail.

C. Chain link fabric shall be taut and shall be attached to posts, rails, and wires with galvanized fabric bands or tie wires at a maximum spacing of 12 inches on posts and 18 inches on the rails and tension wires. Stretcher bars shall be provided at ends of fabric. The bottom tension wire shall be stretched tight and shall be located 2 inches maximum above finished grade and on a straight grade between posts by excavating the high points of ground, and in no case shall depressions be filled.

D. Unless otherwise specified, three strands of barbed wire attached to extension arms shall be provided along the fence top. Extension arms shall overhang the outside of the fence at a 45-degree angle. The topmost strand of barbed wire shall be 12 inches above the top of the fabric.

E. Provide a continuous brace rail set 1 ft below top rail. All fence panels to include

3.03 GATES

A. See Manufactuers Instructions and Section 32 31 15 Hydraulic Vertical Pivot Gate System

B. Gate frames shall be fabricated with welded joints or rigid connectors. The fabric shall be the same as that used for the fence and shall be rigidly attached to the frames. Frames shall be suitably braced and trussed. Gates shall be equipped with suitable offset hinges to permit a 180-degree swing and a drop bar locking device with provision for padlocking. A stop to hold the gate open and a center rest with catch shall be provided. Unless otherwise specified, three strands of barbed wire shall be provided on top of chain link gates.

3.04 FIELD QUALITY CONTROL

A. Installer Qualifications: Firm approved by manufacturer or with minimum five years successful experience completing vertical pivot gate installation similar to that required.

B. Pre-installation Conference: Conduct meeting at site prior to commencing work related to vertical pivot gate operator system installation.
   1. Require attendance of parties directly affecting vertical pivot gate operator installation.
   2. Review site conditions, procedures, and coordination required with related work.

C. Field Measurements: Verify dimensions and component layout by field measurements prior to beginning installation.

D. Gate Tests: Prior to acceptance of installed gates and gate operator systems, demonstrate proper operation of gates under each possible open and close condition specified.

E. Provide manufacturer's standard limited warranty for gate operator system and system components against failure resulting from normal use based on manufacturer's literature.
   1. Failure shall be defined as any defect in manufacturing which prevents gate from operating as intended.
   2. Warranty Period: Three years.

END OF SECTION

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32 31 15

HYDRAULIC VERTICAL PIVOT GATE SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Provide vertical pivot gate system including gates and special Tilt-A-Way hydraulic operator, with accessories as required for complete operational installation. Tilt-A-Way vertical pivot gate systems are UL 325, and CSA C22.2#247 listed.

B. Related Sections:
   1. Section 32 31 13: Chain link fences and gates.
   2. Division 3: Concrete support slab.
   3. Division 26: Electrical connections.

1.02 SYSTEM DESCRIPTION

A. Performance Requirements:
   1. Safety Devices: Provide manufacturer's standard safety devices including the following features.
      a. Provide pressure relief valve to avoid crushing obstruction encountered in either direction of travel.
      b. Provide shut off power device if balance system fails.
   2. Power Failure: Provide manual bypass system, which allows barrier to be opened and to be closed in event of power failure.
   3. Operation: Design system to allow for a minimum of 2900 open and close operations per day.

B. Gate Height: Total height 7-ft. 6 ft line post with 1ft extension for 3 lines of barbed wire. Match Barrier Style Patriot.
   1. [Note: Gate widths from 25 feet wide or up to 50 feet total width for two vertical pivot gate operators are possible with aluminum barriers, up to 40 feet total width for steel barriers, with no center posts, overhead supports, tracks, or special framing required.]

C. Gate Width: Provide widths as indicated on drawings. Provide 2 vertical pivot gates operators for greater than 25 ft wide entrance.

1.03 SUBMITTALS

A. Product Data: Furnish manufacturer's literature for gate and operator and each manufactured accessory required for Project.
   1. Wiring Diagrams: Furnish manufacturer's wiring diagrams for gate operator.
   2. Maintenance Data: Furnish manufacturer's operators and parts manual.

B. Shop Drawings: Show location of vertical pivot gates system in relationship with adjacent fencing and paving, details of installation, hardware locations, and accessories.
   1. Templates: Provide drawings or templates for installation of anchor bolts in support slab.

C. Certificates: Furnish manufacturer's certification indicating system provided complies with specified requirements.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Firm approved by manufacturer or with minimum five years successful experience completing vertical pivot gate installation similar to that required.

B. Pre-installation Conference: Conduct meeting at site prior to commencing work related to vertical pivot gate system installation.
   1. Require attendance of parties directly affecting vertical pivot gate installation.
   2. Review site conditions, procedures, and coordination required with related work.

1.05 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions and component layout by field measurements prior to beginning installation.

1.06 WARRANTY

A. Provide manufacturer's standard limited warranty for system and system components against failure resulting from normal use based on manufacturer's literature.
   1. Failure shall be defined as any defect in manufacturing, which prevents the gate from operating as intended.

B. Warranty Period: Three years.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Ideal Manufacturing, Inc., 2011 Harnish Blvd., Billings, MT 59101.

Telephone 800-523-3888 or 406-656-4360; Fax 406-656-4363.

Web address: www.tilt-a-way.com; E-mail: info@tilt-a-way.com

2.02 MANUFACTURED UNIT

A. Vertical Pivot Gate System: Ideal Mfg., Inc. /TILT-A-WAY Model HYJG.

2.03 COMPONENTS

A. Hydraulic Power Unit: 1 HP TEFC motor, 1725 RPM, 220 VAC Single Phase Spencer Hydraulic power unit capable of delivering 4 GPM at 385 PSI, with external adjustment relief valve and 4-way solenoid operated 3-position manual override valve.
   1. Hydraulic pump, motor, and reservoir will all be as one unit with fluid thermometer and fluid level sight gauge.
   2. The hydraulic system will be designed to keep the gate locked in the closed position, keeping any person from lifting the gate open when it is in the closed position.
   3. Pedestal Frame: Welded construction with removable outer skin of cross break corrosion resistant painted gray .063 aluminum plate panels.
   4. Inspection Door Hardware: Stainless steel continuous hinges and heavy-duty lockable pull down catches to hold inspection door shut.
   5. Power: [208 / 230 VAC Single Phase] 3 Wire.
      a. The total gate system requires 20-amp service, with no more than 3% drop in voltage, while gate is in operation. Note: If your installation requires 110 volts AC run a neutral wire (208 / 230 VAC Single Phase 4 Wire). (FOR WIRE SIZE: CONSULT LOCAL ELECTRICAL CODE.)

B. Hydraulic System: 3000-psi hydraulic cylinder.
   1. Cylinder: 2-1/2" by 38" stroke hydraulic cylinder with 1-3/8" diameter rod, limit switches and cushioned slow down on each end of travel, and adjustable stops with lock down in any position.
   2. Hydraulic Fluid: Manufacturer's standard, factory checked, filled, and tested.

C. Balance System: System designed to allow barrier to be hand raised and to be hand lowered with 12 to 15 pounds of pressure, consisting of manufacturer's standard cables, sheaves, sealed cam yoke roller bearings, and tension springs pulled in a straight line.
   1. Safety Control Switch: Provide built-in safety control switch capable of stopping barrier in any position should balance system fail.
   2. Testing: Factory test and adjust balance system to ensure gate may be manually raised and lowered with specified pressure.
   3. Signage: Signage to be added to the gate barrier must be declared at the time of order so the manufacturer can add the signs on the barrier, to ensure Ideal Mfg. balances the operator correctly at the time of manufacturing.

D. Electrical System: Oversized rain tight enclosure housing electrical components except limit switches, safety switches, and motor.
   1. Wire: Oil and gasoline resistant.
   2. Overload Protection: Allen Bradley type overload protection relay to protect motor.
   3. Reversing Controller: Provide as required to operate motor and solenoid valves.
   4. Overrun Delay Timers: Integral to board capable of shutting down system in case motor runs longer than 30 seconds.
   5. Limit Switches: Adjustable snap action style limit switches capable of stopping barrier at each end of travel.
   6. Logic Board: Programmable logic board with manufacturer's full range of available functions.

7. All gates are equipped with a dry contactor to accommodate all types of access equipment.
    a. [Note: Coordinate selection of following options with manufacturer.]
8. Options:
    a. Cold Weather Package: (required in areas where the temperature drops to less than 35° F).
    b. Stanchion: (this is for the free end of the gate).
    c. Radio Controls: Provide standard open-close-stop commercial transmitters/receivers systems.
    d. Loop Detectors: Provide detector system (except loop) to allow free exit/safety, safety, or close gate operation; system to be factory wired inside electrical box and tested.
    e. Reversing Edge: Provide manufacturers standard reversing edge system.
    f. Synchronizing Box: Master slave system for paired gate system (required only when 2 gates operate in conjunction with each other).
    g. Gate Status Lights: Provide light stacks indicating gate status: such as green light indicates barrier is open; red light indicates barrier is closed; and amber flashing indicates barrier is moving.
    h. Locks: Magnetic lock secures gate in closed position.
    i. Photo Eye: Used as a form of safety.
    j. S.O.S.: Siren Operated Sensor (emergency access system)
    k. Stainless steel fasteners.
    l. Heater for Electrical Box: Provide heater, including full box insulation to protect system for conditions to -70° F.
    m. Ice Scrapers: (for cable sheaves).
    n. Weather Guard Package.
        1) *[Note: Coordinate selection of systems with vertical pivot gate system manufacturer.]*
    o. Access Control Systems:
        1) Key switches.
        2) Keypads.
        3) Card readers.
        4) Intercom stations.
        5) Proximity card readers.
        6) Phone access systems.
        7) Fire access systems.
        8) Pedestals.
        9) Closed circuit television.
        10) Infrared detectors.

E. Barrier System (Gates): Design to resist twist and to resist sway.
   1. Type: Manufacturer's standard aluminum barrier (up to 25 foot wide opening per gate leaf), nominal 3.125" by 2.875" diamond 6063-T5 alloy aluminum screen fabric (amplimesh) welded both sides completely, with sway bracing. Leading member of an aluminum barrier 4" schedule 40 round tube, sway braces- 1 ¼ x 1 ¼ x 1/8 square tube uprights- 2 x 2 x .188 square tube. Sway braces bolted to barrier. Barriers with sway braces are designed to withstand 100 MPH wind load, or optional 150 MHP sway bracing.
   2. Type: Custom barrier as indicated on Drawings, with sway bracing.
   3. Options: Provide stanchion to contain free end for severe crash applications; match barrier.

F. Accessories: Provide as required for complete operational installation.
   1. Child Guards: Provide child and small animal guard on secured side of operator.

2.04 FINISHES

A. Finish: Factory prime with DTM epoxy and paint with Gensis acrylic urethane topcoat to resist corrosion.
   1. Color: [As selected from manufacturer's standard colors.] [Custom color as indicated on Finish Schedule.]
   2. The manufacturer's standard color is Sherwin Williams Gray.
   3. Specify color of gate if different from manufacturer's standard color.
   4. If a color (other than standard gray) is ordered the operator panels will be made with 16 gauge aluminum.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Verify concrete support slab complies with requirements and verify anchors and conduits are properly installed
   1. Ensure alignment with adjacent construction, fencing, and paving, coordinate with adjacent construction.

3.02 INSTALLATION

A. Comply with manufacturer's recommendations and installation instructions.
   1. Install vertical pivot gate system to provide rigid and secure installation as indicated, straight and true to lines and levels indicated, for free, effortless operation.
   2. Install components square and level, accurately fitted and free from distortion and free from defects.

B. Advise Owner regarding programmable features and controls and preset controls according to Owner requirements.
   1. Instruct Owner personnel in proper operation, maintenance, and reprogramming of system.

3.03 PROTECTION

A. Protect vertical pivot gate system from damage during remainder of construction operations; replace components damaged by subsequent construction operations.

B. Touch-up scratched and damaged surfaces using same primer and finish system applied in shop.

END OF SECTION

SECTION 32 80 00

LANDSCAPE IRRIGATION SYSTEM

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The CONTRACTOR shall construct an automatic irrigation system, complete and operable, in accordance with the requirements of the Contract Documents.

B. Said irrigation system shall include but not be limited to all pipes, fittings, irrigation drip emitters, valves, pump assemblies, automatic control valves, controller, valve boxes, drain valves, quick coupler valves, operating wrenches, riser assemblies, direct burial wires, electrical connections, filter, wiring and other appurtenances, piping, connections, testing, cleaning-up, maintenance and adjustments necessary for a complete operating system, ready for immediate use upon completion. Minor items necessary for proper construction and functional operation of this system, not specifically described in the Contract Documents, shall be included as a part of the work of this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes, as referenced herein, are as specified in Division 01.

B. Commercial Standards:

ASTM B 3	Specification for Soft or Annealed Copper Wire
ASTM D2564	Specification for Solvent Cements for Poly (VinylChloride) (PVC) Plastic Pipe and Fittings
AWWA C 500	Gate Valves for Water and Sewerage Systems

1.03 CONTRACTOR SUBMITTALS

A. Manufacturer's literature, samples (where requested by the Owner) and installation instructions shall be submitted in accordance with Division 01 Section “Contractor Submittals."

B. Record drawings, showing actual locations of all valves, pipes (lines), heads, dimensions, controllers, control lines, and electrical wires shall be submitted prior to final inspection. Diagrammatic location of irrigation system components is not acceptable when submitting record drawings – actual location of irrigation system equipment is required for locating in the field.

1. Actual routing of mainline with dimensions from fixed points.
2. Actual routing of control wiring with dimensions from fixed points.
3. Location of wire splices (must be placed in valve box and only use splices in approved locations)
4. Actual routing of lateral lines and head locations
5. Actual location of valve boxes with notes on type of valve used at each location.
6. Actual location of sleeves with dimensions from fixed points.
7. Actual location of stubbed mainlines or lateral lines (if applicable)

8. Provide legend of symbols/notes used on record drawings.
9. Any other notes as necessary to enable the owner to understand and locate irrigation system equipment in the field upon completion of the project.

C. Controller literature, specifications, installation wiring diagram, and circuit breaker information shall be submitted to the OWNER for review prior to ordering.

D. Equipment for Operation: The CONTRACTOR shall provide the following equipment, in addition to what is indicated on the Drawings.
1. Two keys for locking automatic controller door.
2. One Gate valve key.
3. Two keys for locking valve boxes.
4. 2 Valve Keys for Quick Coupler – coordinate with Owner.
5. One Valve Key for Manual Drain Valve.

E. A reduced copy of the irrigation plan shall be laminated and mounted in the controller.

1.04 QUALITY ASSURANCE

A. In addition to other inspections, as provided by the OWNER, the CONTRACTOR shall give at least 72 hours' notice to the OWNER for scheduling the following special inspections:
1. Layout of the system
2. Inspection of trenches, backfilling, and equipment.
3. Pressure tests
4. Coverage adjustment
5. Automatic operation

B. The CONTRACTOR shall notify the OWNER at least 72 hours prior to performing the tests. All tests shall be performed in the presence of the owner's representative. Test requirements shall be as follows:
1. After assembly and installation, all water pipes, fittings, automatic equipment, and appurtenances shall be tested at a hydrostatic pressure of 150 psi at the lowest point of the system for not less than 60 minutes.
2. The first test shall be made in such a manner that all valves in the new water pipe irrigation lines will be tested for watertight closure. Valves may be tested in groups or singly while subjected to 150 psi water pressure for a period of not less than 60 minutes.
3. The second test shall be made by forcing all air from the pipes with water and capping or plugging pipe risers. After the pipe risers have been plugged or capped, all line valves shall be fully opened, and the pipelines subjected to the full static water pressure for a period of not less than 120 minutes. Pressure pipelines 150 PSI).
4. The third test required that lateral lines be tested at 100 psi for 120 minutes.
5. The fourth test requires that all pressure lines be tested at 120 psi for 24 hours.
6. Water lines and valves which show evidence of leakage or fail to be watertight shall be repaired or replaced. After all repairs or replacements have been made, the above-required tests shall be performed again.

7. When the irrigation system is completed, the CONTRACTOR, in the presence of the OWNER, shall test coverage of water afforded the lawn and planting areas. The CONTRACTOR shall furnish all material and perform all the work required to correct any inadequacies of coverage disclosed. The CONTRACTOR shall inform the OWNER of any deviation from the Drawings required due to wind, planting, soil, or site conditions that bear on proper coverage.
8. Upon completion of each phase of the work, the CONTRACTOR shall check and adjust each irrigation head to meet the site requirements and the requirements of the Contract Documents.
9. (Testing as noted in 1 through 5 is at the owner's option, and generally will not be required unless verification of the contractor's workmanship and quality is required.)

C. Certifications: All General laborers or workers on the Project shall be previously trained and familiar with sprinkler installation and have a minimum of one year's experience. Those workers performing tasks related to PVC pipe and electrical components shall have certificates designated below:
   1. Certified Irrigation Contractor
   2. All workers engaged in handling, assembling, and gluing of PVC pipe shall carry on Project site a Certificate of Training from the IPS factory representative authorizing said worker to prime and glue PVC pipe.
   3. All Workers engaged in the installation of irrigation pipe, which is assembled using joint restraint fittings, shall carry on project site; a Certificate of Training from authorized representative of Ductile Iron Fitting Manufacturer, (HARCO, Leemco, or approved equal) indicating:
      a. Contractor firm has been adequately trained in installation of joint restraints to replace thrust blocking.
      b. Authorizing said worker to install Ductile Iron fittings, joint restraints, isolation line valves, manifold isolation valves.
   4. Documents verifying Certified Irrigation Contractor, PVC Pipe Certification, Electrical Component Certification, and Joint Restraint Systems shall be provided to Owner's Representative at least 30 days in advance of any irrigation installation on project site.

1.05 INSTRUCTION

A. The CONTRACTOR shall, upon completion of the maintenance period of the irrigation instruct the OWNER and the OWNER'S personnel as to the proper operation and maintenance of the system.

1.06 EXISTING UTILITIES AND CONDITIONS

A. Prior to cutting into the soil, the CONTRACTOR shall locate all cables, conduits, sewers, septic tanks, and other such underground utilities, and shall take proper precautions not to damage or disturb such improvements. If a conflict exists between such obstacles and the proposed work, the CONTRACTOR shall promptly notify the OWNER.

B. The CONTRACTOR shall be responsible for coordinating its work with the operation of existing utilities and new utilities on the Project. The CONTRACTOR shall notify the OWNER or its representative when utilities which are in operation require shut-off.

C. Due to the scale of Drawings, it is not possible to indicate all offset, fittings, etc., which may be required. The CONTRACTOR shall carefully investigate the structural and finished conditions affecting all its work, and plan its work, accordingly, furnishing such fittings, etc., as may be required to meet such conditions. The Contract Documents are generally diagrammatic and indicative of the work to be installed. The work shall be installed in the most direct and workmanlike manner, so that conflicts between irrigation systems, planting, structures, piping, etc. will be avoided.

D. The CONTRACTOR shall verify the water pressure available at the site before installation of the system to make sure there is adequate pressure (design pressure 30 to 40 psi) to properly operate irrigation heads and valves and shall also provide pressure reducing valves if required before commencement of any work. Minor additions and adjustments of heads, piping, and circuits shall be made at no additional cost to OWNER where it is necessary to make the irrigation system operate properly.

1.07 STORAGE OF MATERIALS

A. The CONTRACTOR shall be responsible for storage of materials and for damage to the WORK covered by these Contract Documents before final acceptance of its work. The CONTRACTOR shall securely cover openings into the system, and shall cover all apparatus, equipment, and appliances both before and after being set in place to prevent obstruction in the pipes and the breakage, misuse, or disfigurement of said apparatus, equipment, or appliances.

1.08 SCHEDULING AND COORDINATION

A. The CONTRACTOR shall be responsible for deciding for the coordination of its construction operations with those of all others on the job. The CONTRACTOR shall permit others engaged in work to accomplish their portion of the WORK without undue interference or delay.

B. The CONTRACTOR shall be responsible for the scheduling and coordination of the electrical and water connections and the installation of the piping and equipment in a manner that will affect the earliest completion of the WORK in conformance with the construction progress schedules.

C. If electrical service is not already in place, the Contractor will be required to make all necessary arrangements with the power utility company including, but not limited to, paying fees, making power connections, providing poles, weatherhead and meter, etc., as specified on the plans. All permits, fees, and compliance with electrical company requirements shall be the Contractor's responsibility.

1.09 GUARANTEE/WARRANTY OF THE IRRIGATION SYSTEM

A. The CONTRACTOR shall guarantee the complete irrigation system to be free from leaks or breakage due to defective material or workmanship for a period of one year from the date of acceptance of the complete work by the OWNER. Damage due to sabotage and/or vandalism is specifically excepted from this guarantee.

B. Other items of the required guarantee shall be as specified in the Division 32 Section “Landscape Planting”.

C. The CONTRACTOR shall repair any settling of backfilling trenches occurring during a one-year period after final acceptance without expense to the OWNER including complete restoration of all damaged planting, paving, or other improvements of any kind.

D. The CONTRACTOR shall provide winterization of the irrigation system during the one-year guarantee period.

E. When defective material or workmanship is discovered which will require repair or replacement, all such repair work or replacement work shall be done by the CONTRACTOR at its own expense within 24 hours after written notification is given to the CONTRACTOR by the OWNER of such required repairs. However, if the CONTRACTOR fails to comply with the requirements of the above guarantee within the 24 hours after notification is given, the OWNER shall proceed to have the repairs made by others at the CONTRACTOR'S expense.

PART 2 PRODUCTS

2.01 GENERAL

A. Brand names specified for materials are supplied for the purpose of describing the type, size, quality, and performance of materials in the Irrigation Schedule. The CONTRACTOR may propose other manufacturers and models, as substitutions for those other than indicated in the Irrigation Schedule, if the materials are of equal quality and performance to the OWNER for review in accordance with Division 01 Section "Contractor Submittals." Any proposed irrigation equipment submitted by the contractor for approval as proposed substitution shall hydraulically match the originally specified equipment in the Drawings (i.e., flow rate, precipitation rate, friction loss, etc.)

B. The CONTRACTOR shall furnish, at no additional charge, all samples necessary for testing as outlined in the Specifications or, when requested, certified evidence of off-site testing.

C. Equipment compatibility: automatic controller and automatic (remote) control valves shall be products of the same manufacturing company.

D. The electrical point of connection for the irrigation system automatic controller shall be 120-volt electrical supply or as per manufacturer’s recommendations.

2.02 PLASTIC PIPE AND FITTINGS

A. Pipe shall be continuously and permanently marked with the following information: manufacturer's name, nominal pipe size, PVC type, pressure rating, and extrusion date.

B. All plastic pipes for lateral lines shall be PVC (polyvinyl chloride) SDR 21, Schedule 40, NSF approved.

C. Materials for pressure main lines shall be PVC (polyvinyl chloride) SDR 21, Schedule 40, NSF approved, or galvanized steel pipe.

D. Pipe and Fittings Table:

Size	Mainline Piping	Mainline Fittings	Lateral Piping	Lateral Fittings
1"	SCH 40	SCH 40	SCH 40	SCH 40
1-1/4"	SCH 40	SCH 40	SCH 40	SCH 40
1-1/2"	SCH 40	SCH 40	SCH 40	SCH 40
2"	SCH 40	SCH 80	SCH 40	SCH 80
2-1/2"	SCH 40	SCH 80	SCH 40	SCH 80
3"	SCH 40	SCH 80	SCH 40	SCH 80

E. Ductile iron fitting shall be grade 65-45-12 in accordance with ASTM A-536. Fitting shall be deep bell push-on joints with gaskets meeting ASTM F-477. Fittings shall be Harco Deep Bell or approved equal. Transition gaskets are not allowed.
   1. All Ductile Iron fittings shall include Joint Restraints at each fitting.
   2. All Ductile Iron fittings shall come from a manufacturer offering a 10-year warranty on products and replacement labor costs. Prior to install, Contractor shall provide OAR documentation from the manufacturer shall provide documentation stating the above warranty information, including the labor reimbursement hourly rate.
   3. All Ductile Iron fittings and joint restraints shall have a fusion bonded epoxy coating on interior and exterior of the product surface, average of 10-12mm thickness. Epoxy coating shall conform to the requirements of CSA Z245.20-20 and NSF 61 for water services. Tar/bitumen coating will not be approved.
   4. All bolts used in fittings to be stainless steel.

F. Swing joint ells and nipples shall be Schedule 80 PVC or galvanized as noted on Drawings.

G. Control wiring conduit
   1. rigid non-metallic schedule 40 PVC
   2. UL listed: meets requirements of UL 651.

2.03 VALVES

A. Gate valves shall be as indicated on the Drawings.

B. Master valves shall be as indicated on the Drawings.

C. Isolation valves for valve manifolds shall be as indicated on the Drawings.

D. Remote Control Valves shall be as indicated on the Drawings.
   1. Each group of remote-control valves shall be housed in a poly plastic valve box with locking lid and gravel base.

E. Quick-coupling valves shall be as indicated on the Drawings.

F. Manual drain valves shall be as indicated on the Drawings.

2.04 AUTOMATIC CONTROLLER

A. Shall be as indicated on drawings.

2.05 DRIP EMITTERS

A. Drip Emitters shall be the model and type indicated on the Drawings.

2.06 BACKFLOW PREVENTER

A. Backflow Preventer shall be the model and type indicated on the Drawings.

2.07 FLOW SENSOR

A. Flow Sensor shall be the model and type indicated on the Drawings.

2.08 CONTROL WIRING

A. All splices shall be made with wire connectors, such as manufactured by 3M DBY or approved equal.

B. Electric Control Wire shall be Polyethylene (PE) UF DIRECT BURIAL type. The wire which is routed from the Electric Remote-Control valve to the controller shall be #14 AWG.

C. Use PE-39 shielded communication cable for flow sensor and master valves.

2.09 PVC SOLVENT CEMENT AND PRIMERS

A. Solvent Cement shall be NSF approved and shall meet the requirements of ASTM D 2564.

B. The Primer shall be NSF approved and shall be Weld-On, P-70 Industrial Polychemical Service or approved equal.

2.10 VALVE AND CONTROLLER BOXES

A. Boxes for valves shall be heavy duty plastic Rain Bird, Carson-Brooks, complete with locking lids, or approved equal.

B. Boxes and lids shall be tan color in shrub beds and green turf areas.

PART 3 EXECUTION

3.01 GENERAL

A. Installation of the irrigation system shall be performed after the finish grading, but prior to landscaping.

B. All valves, fittings, drip emitters, and piping shall be installed as indicated on the Drawings and all connections made to permit the irrigation system to function properly through its entire length.

C. All materials and equipment shall be installed in strict accordance with the manufacturer's written instructions and recommendations and all local and state codes, laws, ordinances, and regulations.

D. Before proceeding with the installation of any section or unit of the irrigation system, the CONTRACTOR shall check and verify the correlation between ground measurements and Drawings and shall advise the OWNER of any discrepancies.

E. The total number of irrigation drip emitters and circuits and size of pipes shall be not less than shown unless otherwise approved. The stated maximum spacing for each type of irrigation drip emitters shall not be exceeded.

3.02 EXCAVATION

A. Trenches shall be dug as wide and as deep as necessary to properly install the irrigation pipe.

B. Pipe trenches shall be straight, or "snaked" slightly allowing for expansion and contraction of PVC pipe.

C. Subsoil shall be kept separate from topsoil, where possible.

D. Minimum cover depth shall be as follows:
   1. Supply pressure lines from water source to control valves: 18 inches unless otherwise indicated on the Drawings.
   2. Lateral lines from control valves to irrigation drip emitters; 8 and 16 inches unless otherwise indicated on the Drawings. Lateral lines under paving, roadways, and driveways shall have 18 inches of cover and located in Schedule 40 PVC sleeves
   3. Trenches for control wire only shall be 18 inches deep unless otherwise indicated on the Drawings. Control wires under concrete walks and slabs, paving, roadways, and driveways shall be installed in Schedule 40 PVC sleeves.

E. A trench of sufficient width shall be provided to allow for proper tamping around pipe.

3.03 PIPING-GENERAL

A. Piping shall be laid out and installed in accordance with manufacturer's printed recommendations and industry standards. Substantial support shall be provided at all points, and pipes shall be snaked slightly allowing for expansion and contraction.

B. Minimum 1-inch vertical clearance shall be between lines crossing at angles greater than 45 degrees.

C. Minimum 3 inches horizontal and vertical clearances shall be between all other lines.

D. All swing or swivel joints shall provide a leak-resistant joint with freedom of movement.

E. Teflon thread sealant 3/4-inch wide (tape or liquid) or approved equal shall be used at all threaded joints.

F. Galvanized steel pipes shall have clean standard threads of standard lengths. Joints shall be made up with pipe compound applied to male threads only and not more than 2 threads shall show at the joints when connected.

G. Pipe sleeves shall be provided under all paving and where necessary for passage under finish surface material, future replacement, and for protection of PVC piping and control wire.

3.04 PLASTIC PIPE

A. The pipe shall be guaranteed by the manufacturer to be suitable for operation under the conditions of this installation and shall be guaranteed free from defects in workmanship and quality.

B. The pipe shall be connected by O-ring type or by solvent-weld joints as outlined below. Joints shall be made in strict accordance with the manufacturer's printed recommendation.

C. The plastic pipe sections shall be placed accurately to line and grade in the prepared trenches. The inside of all pipes shall be clean and free from foreign matter and shall be end-reamed to remove burrs and provide full inside diameter of the nine end.

D. Pipe assembly shall have a firm, uniform bearing for the entire length of each pipeline to prevent uneven settlement. All adjustments to grade shall be made by scraping away or filling in with clean earth backfill material, well compacted under the body of the pipe. Wedging of pipe will not be permitted. The inside of all pipes shall be clean and free from foreign materials before joints are assembled.

E. Sealant tape shall be used on all threaded joints.

F. All pipeline open ends upon which the WORK has been stopped shall be closed at the end of each day's construction work with a suitable temporary plug to prevent entrance of any foreign materials into the assembled pipeline.

G. Pressure pipe shall be defined as all piping lying "upstream" from remote control valves and quick-coupling lines.

H. Joint Restraint System
   1. All ductile iron pipe fittings and mainline gate valves shall be restrained by the joint restraint system. Fittings shall require a ‘fitting to pipe restraint’ and mainline gate valves shall require a ‘valve to pipe’ restraint. When required by manufacturer, gasket bell ends of pipe shall require a ‘pipe to pipe’ restraint.
   2. Concrete thrust blocks shall not be used.
   3. Joint restraints are needed on pipe sized 3” and larger, wherever the main pipeline:
      a. Changes any direction at tees, angles, and crosses vertical and horizontal.
      b. Changes size at reducers.
      c. Stops at a dead-end.
      d. Valves at which thrust develops when closed.

4. The size and type of joint restraint system depends on a number of factors, including pressure, pipe size, kind of soil, and type of fitting. Refer to detail table, as well as manufacturer's recommendations for proper sizing and types.

I. All pipes, lines, and risers shall be flushed thoroughly with water before installation of any drip emitters. All debris and rocks found at that time shall be removed from the area as soon as possible.

J. The areas noted on the details table shall be measured in a place perpendicular to the longitudinal axis of the pipe or to the longitudinal axis of the thrust developed. The thrust block bearing area shall be against undisturbed around.

K. Compression fitting (compression by compression slip joint PVC) shall be provided on mainline at 250 on center for expansion and contraction of mainline on straight runs on solvent welded pipe.

3.05 VALVES

A. Piping systems shall be supplied with valves at all points as indicated on the Drawings or specified herein so arranged to give complete regulating control throughout. Automatic control valves and gate valves shall be as detailed in the Contract Documents or as otherwise directed by the OWNER.

B. Valves shall be the full size of the line in which they are installed, unless otherwise indicated on the Drawings.

C. Remote control valves shall be adjusted so the most remote irrigation drip emitters operate at the pressure recommended by the drip emitter manufacturer. Remote control valves shall be adjusted so a uniform distribution of water is applied by the irrigation drip emitters to the planting areas for each individual valve system. A union fitting shall be provided on the discharge side of the control valve. They shall be wired to operate in the order as shown. They shall be capable of being operated manually entirely independent of the controller.

D. Isolation shall be installed as indicated on the Drawings.

E. Manual Drain valves shall be installed where indicated on the Drawings.

F. Quick-coupling valves shall be provided, located, and installed as indicated on the Drawings.

3.06 VALVE BOXES

A. All valve assemblies shall be installed as indicated on the Drawings.

B. Install all Valve Boxes no closer than three feet from sidewalks, curbs, and all hard surfaced areas. Where three feet clearance from hardscape is not possible, locate the valve box as far as practical from areas of vehicle traffic. Do not install Valve Boxes at the low point of the landscaping.

C. Limit the number of valves per valve box. The maximum number allowed in each box is:

Valve Box Size	Electric Valve Size and Quantity
Standard Valve Box	One Valve per Box
Jumbo Valve Box	One 2" Valve, or Two 1-1/2" Valves, or Two 1" Valves
Little Giant	Two 2" Valve, or Three 1-1/2" Valves, or Three 1" Valves
Giant	Three 2" Valve, or Four 1-1/2" Valves, or Four 1" Valves

3.07 IRRIGATION DRIP EMITTERS

A. All irrigation drip emitters shall be installed as detailed in the Drawings.

B. The irrigation system shall be thoroughly flushed remove all possible foreign material prior to installation of the irrigation heads.

C. The CONTRACTOR shall protect against re-entry of contaminated water into risers or piping. After flushing, the CONTRACTOR shall immediately install irrigation drip emitters.

3.08 CONTROLLER

A. The CONTRACTOR shall connect to the controller as indicated on the Drawings.

B. Controller location is essentially diagrammatic, and field verify exact location with Owner's Representative.

C. Adjustment of the controller shall be such that each control valve in the circuit will remain open for a readily adjustable period of 5 or less minutes to 60 minutes. Readily made field adjustments shall include a provision whereby any number of days in a week can be skipped and whereby one or more positions on the controller may be skipped. When any or all of the above adjustments have been made, the controller shall continue to operate automatically as set until further adjustments are made. Provision shall be made for conveniently resetting the start of the irrigation cycle at any time and for advancing from one position to any other position at will.

D. Timing, sequence, and period will be supplied to the CONTRACTOR by the OWNER. At this time, the CONTRACTOR shall adjust the controller for normal operation.

3.09 FLOW SENSOR AND MASTER VAVLE

A. Wire flow sensor and master valve directly to controller using PE-39 shielded communication cable.

B. Maintain manufacture recommended distances up and downstream of flow sensor.

3.10 WIRING AND ELECTRICAL WORK

A. All electrical equipment and wiring shall comply with local and state codes and shall be installed by those skilled and licensed in the trade. Unless the governing codes specify otherwise, low voltage control wire may be installed by the CONTRACTOR when code allows.

B. All 110-volt wire shall be installed in conduit and taken from appropriate sources as indicated on the Drawings. CONTRACTOR shall coordinate manufacturer and installer.

C. The CONTRACTOR shall provide low voltage, 24-volt direct burial wires. Wire size shall be as shown but shall be not less than No. 14. Where sizes are not shown, they shall be sized per wire manufacturer's sizing charts and specifications.

D. The CONTRACTOR shall provide all wiring, conduits, sleeves, and connection for the low voltage electrical system between controller and valves, and where else shown and necessary for a complete and operable irrigation system.

E. All splices shall be moisture proof using specified electrical connectors.

F. An expansion curl should be provided within 3 ft of each wire connection and at pull box locations. Provide three feet of extra wire in each valve box.

G. All conduits and sleeves necessary for running wires under concrete, walks, and paving shall be furnished and installed before said concrete, walks, and paving work is installed.

H. Wire shall be continuous without splices except at control valves and shall be routed in main line trench whenever possible.

I. Install 2 extra wires (blue) to the last valve box in each run.

J. Wiring color:
   1. Common: white
   2. Valve: red
   3. Spare: blue

3.11 PIPE TRENCH BACKFILL

A. After pipe and wires have been installed and approved by the Owner’s inspection, the trenches shall be backfilled. The backfill operation must provide a firm continuous support for the pipe.

B. Backfill material shall be free of rocks and other materials that may damage the piping.

C. Bottom of trenches shall be smooth and free of sharp rocks and other object that may damage pipe.

D. The initial backfill shall be accomplished by carefully tamping selected material (from material excavated from the trench) under the pipe and between the pipe and the trench.

E. The pipes shall be filled with water and pressurized during backfilling operations, if necessary, to prevent drainage to piping.

F. The backfill shall be carefully installed around and over the pipe to approximately 10 inches of the ground surface, then water shall be allowed to flow in the trench. After this puddling operation has been completed and allowed to stand for 24 hours, the balance of the materials shall be placed in the trench to the sub-grade line (leaving room for topsoil) Rocks and other materials found in the backfill shall be removed. The backfill shall be compacted carefully and thoroughly.

G. Couplings and fittings shall be left exposed until leakage tests have been completed.

H. Topsoil shall be installed prior to planting.

I. Install detectable warning tape as indicated on the Drawings.

3.12 TESTING AND ADJUSTMENTS

A. The OWNER shall be notified by the CONTRACTOR prior to performing hydrostatic tests on the irrigation system in place. This test shall be done by the CONTRACTOR in the presence of the OWNER. The test results will be acceptable to the OWNER when no leakage or loss of pressure is evident during the test period. Defects shall be detected and repaired prior to retesting.

B. The irrigation drip emitters shall be adjusted and balanced for optimum and uniform coverage without excessive fogging and overthrow on walks, paving, and structures. The height and elevations of risers and irrigation heads shall be adjusted.

C. Following adjusting and balancing of the irrigation heads, an operating test of the entire system shall be performed by the CONTRACTOR in the presence of the OWNER at normal operating pressures. The test will be considered as acceptable if the system operates in a satisfactory manner providing uniform coverage of irrigated areas for a one-week period of automatic operation with no leaks.

3.13 RECORD DRAWINGS

A. Record Drawings shall be furnished to the OWNER at the time of the irrigation system inspection and before acceptance of the operating system by the OWNER.

3.14 ACCEPTANCE AND OPERATION BY OWNER

A. Upon substantial completion of the work and acceptance by the Owner, the OWNER will issue a date of substantial completion letter to the contractor. Contractor shall be responsible for the training of the owner’s maintenance staff in the operation of the system (provide minimum 48 hours written notice in advance of test). The Contractor shall furnish, in addition to the Record Drawings and operational manuals, copies of all available specification sheets and catalog sheets to the Owner's personnel responsible for the operation of the irrigation system. The Contractor shall guarantee all parts and labor for a minimum period of one (1) year from date of substantial completion.

END OF SECTION

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SEEDING

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PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the methodology and sequencing for establishing the seed mixes prescribed in the design.

B. Dormant seeding: the optimal time to “dormant seed” prescribed native grasses and forbs is when soil temperatures are consistently below 55 degrees Fahrenheit, but above freezing so that seed can work into the soil, approximately September 15 to October 15 in the project region. Seeding when snow is on the ground should be avoided because it reduces seed-to-soil contact and exposes the seed to predation. During this period, the prescribed native cool season species will establish; however, warm season grasses and forbs will germinate in the spring when soil temperatures rise. Dormant seeding enables cold stratification of the seed and allows the seed the earliest germination possible going into the live seeding period.

C. Live or spring seeding: “Live seeding” takes place when soil temperatures are consistently above 55 degrees Fahrenheit, and seed can actively germinate without the risk of a hard freeze. In the project region, live seeding is recommended between April 15 and May 30. Planting after late May is not recommended because the establishment period is a minimum of 120 days after germination. Arid and/or drought conditions in the summer months may prevent seeds from becoming established. Supplemental irrigation is recommended for Live seeding.

D. Disturbed areas outside the permanent seeding dates specified must be stabilized with a temporary seed mix until the permanent stabilization mix can be applied. Permanent seeding mixes shall be implemented in this area during the earliest appropriate seeding window. The Contractor shall apply temporary cover crop to all disturbed areas within 14 days of disturbance.

E. Weather forecasts should be monitored as supplemental watering may be necessary during prolonged dry periods. The seeding sequence should begin within 48 hours after soil preparation to capitalize on existing soil moisture prior to surficial drying. Site stabilization techniques should be used in this 48-hour period. All disturbed areas shall be stabilized no later than 14 calendar days from the date of disturbance in accordance with the standard for permanent construction area plantings.

1.02 MATERIAL

A. SEED
   1. The seed mix – see Section 2.4
   2. Supply seed on a pure live seed basis.

3. Obtain seed from lots that have been tested by a state-certified seed testing laboratory such as Association of Seed Analyst or Society of Commercial Seed Technologists.
    a. Seed germination tests older than 18 months for grass seed and 9 months for shrub or tree seed are not acceptable.
4. Do not use wet, moldy, or otherwise damaged seed.
5. Seed substitutions:
    a. Contact the major seed brokers in the state to verify that the seed is unavailable before requesting a seed substitution.
    b. Obtain approval for a seed substitution.

B. WATER
1. Source: Picinic Site 12 and 13 potable water pump or as designated by SLCDPU.
2. Free of dirt, silt, and other detrimental matter.

1.03 DELIVERY, STORAGE AND HANDLING

A. Deliver materials and products in ultraviolet- and weather-resistant factory-labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from damage, weather, excessive temperatures, and construction operations.

1.04 MAINTENANCE

A. During plant establishment, supplemental irrigation will be required during the first growing season for herbaceous seed mixes.

B. The maintenance work required shall include, but not be limited to, the following:
1. Appropriate watering of seed.
2. Weed treatment and weed removal.
3. Filling and re-compaction of eroded areas, along with any required reseeding and/or replanting.

C. During the first growing season, problem weeds should be hand pulled or spot sprayed with approved herbicides.

D. During the second growing season, problem weeds should be hand pulled or spot sprayed with an approved herbicide.

E. Minimal work shall be required during the winter months, but it is expected that the City and Contractor shall mutually determine when the Contractor shall return for continued maintenance of the site.

F. The contractor shall be responsible for removing the temporary irrigation system after 2 growing seasons.

1.05 WARRANTY

A. Contractor shall guarantee a minimum of 60% native aerial herbaceous coverage after a period of 2 growing seasons from time of execution. Herbaceous coverage may be assessed on an average cover by segmented cells, fields, or blocks. Any individual area greater than 200 square feet with less than 60% aerial herbaceous coverage shall be reseeded as part of the coverage warranty.

B. Noxious and invasive weed species may not be present or established in the restoration area. If weed species are identified during the monitoring and maintenance period, they should be treated and managed according to the City's Invasive Plant Management Plan.

C. The Contractor shall be responsible for additional maintenance or re-seeding efforts if the success criteria is not met after 2 years of monitoring and maintenance.

1.06 SUBMITTALS

A. The Contractor shall submit a letter of certification from the manufacturer that the product meets or exceeds all physical property, endurance, performance, and packaging requirements.

B. The Contractor shall provide written certification that the seed conforms to Utah seed law and is in compliance with Utah State Department of Agriculture regulations.

PART 2 EXECUTION

2.01 PREPARATION

A. Remove the gravel material using grading equipment or shovels, taking care not to disturb the geotextile fabric underneath.

B. Roll up or fold the geotextile fabric in manageable sections, starting from one edge of the installation area and working towards the opposite edge.

C. Store the removed geotextile fabric and gravel material in designated areas for disposal or reuse as appropriate.

D. Install the temporary irrigation system according to the specifications and the design plan sheet.

E. If pertinent, topsoil should be replaced or generated from on-site earthwork. The importation of topsoil should be a last resort and only used as an amendment for "localized" spots that lack the characteristics of a soil seed bed. The topsoil depth should be a minimum of 4 inches spread across the disturbance area.

F. Treat the disturbed area for weeds using herbicide and/or mechanical removal methods. If using herbicide treatment, the chemical compound should be approved by SLCDPU prior to use and be completed a minimum of 2 months in advance of seeding. The application should be in accordance with the product label and instructions.

G. Immediately prior to seeding, use a disk or harrow to run across the land, effectively breaking up the compacted soil surface to facilitate seed germination. Ensure that the equipment is properly sized and adjusted to achieve the desired depth of soil disturbance.

H. Operate the disk or harrow at an appropriate speed to effectively loosen the soil without causing excessive disruption or compaction of the soil structure. The soil should be scarified to maximum depth of 3 inches. Apply seed within 24 hours after seed bed preparation.

2.02 APPLICATION

A. Ensure all components of the disc or drill seeder are clean, lubricated, and in good working condition. Check for any damage or wear on discs, openers, and closing wheels, and replace if necessary.

B. Calibrate the seeder according to the seed type and desired planting rate. Appropriate seed rates for the prescribed seed mix are specified on the design plan sheet.

C. Adjust the depth control mechanism to the desired planting depth based on soil conditions and seed type. The seeds should be sown into the soil 1/8–inch to ¼–inch depth maximum.

D. Fill the seed hopper with the prescribed seed mix and amount of seed. Make sure the seed hopper is clean and remove any debris or foreign materials before loading the seed.

E. Adjust the seeder settings to control the depth at which the seed will be planted and the spacing between seeds. Refer to the equipment manual for specific instructions on how to adjust these settings.

F. Install the seeder according to the manufacturer's instructions. Make sure the seed disk is securely attached and aligned with the seed metering mechanism.

G. Drive across the field at a consistent speed. As the seed disk rotates, seeds are picked up from the seed hopper and deposited into furrows created by the seed opener discs or tubes. Continue planting until the entire disturbance area is seeded, making sure to overlap the seed rows slightly to ensure complete coverage.

H. Water the area immediately after seeding. Monitor soil moisture levels and adjust watering practices accordingly. Avoid waterlogging the seed. Saturating the soil may cause seeds to float or be displaced, leading to uneven seed distribution and poor germination. This is especially problematic in soils with poor drainage.

2.03 IRRIGATION

A. Provide temporary irrigation to establish the seeds. Contractor to obtain a licensed contractor and designer to develop the temporary irrigation system.

2.04 SEEDING MIX INSTRUCTIONS

A. Below table

Seeding Mix Instructions Table

CITY CREEK RESTORATION SEED MIX (3 ACRES)																			
BOTANICAL NAME	COMMON NAME	GROWTH HABIT	INDICATOR (WMVC)	BLOOM PERIOD			POLLINATOR VALUE			WILDLIFE (BROWSE)			SHADE TOLERANCE			APPLICATION RATE (PLS)	SEEDING DATES
				EARLY	MID	LATE	BEES	BUTTERFLIES	OTHER	LOW	MED	HIGH	LOW	MED	HIGH		
ACHILLEA MILLEFOLIUM	COMMON YARROW	HERBACEOUS	FACU													DISC OR DRILL SEED: 15-20 LBS/ACRE	DORMANT SEEDING: SEPTEMBER 15 - OCTOBER 15 LIVE SEEDING: APRIL 15 - MAY 30
ACHNATHERUM HYMENOIDES	INDIAN RICEGRASS	HERBACEOUS	UPL														
BALSAMORHIZA SAGITTATA	ARROWLEAF BALSAMROOT	HERBACEOUS	UPL														
ELYMUS WAWAWAIENSIS	SNAKE RIVER WHEATGRASS	HERBACEOUS	UPL														
CLEOME SERRULATA	ROCKY MOUNTAIN BEEPLANT	HERBACEOUS	FACU														
FESTUCA IDAHOENSIS	IDAHO FESCUE	HERBACEOUS	FACU														
HELIOMERIS MULTIFLORA	SHOWY GOLDENEYE	HERBACEOUS	UPL														
LOMATIUM DISSECTUM	FERNLEAF BISCUITROOT	HERBACEOUS	FAC														
PASCOPYRON SMITHII	WESTERN WHEATGRASS	HERBACEOUS	UPL														
PSEUDOROEGNERIA SPICATA	BLUEBUNCH WHEATGRASS	HERBACEOUS	UPL														
POA SECUNDA	SANDBERG BLUEGRASS	HERBACEOUS	FACU														

SEEDING SPECIFICATIONS

Dormant seeding: the optimal time to “dormant seed” prescribed native grasses and forbs is when soil temperatures are consistently below 55 degrees Fahrenheit, but above freezing so that seed can work into the soil, approximately September 15 to October 15 in the project region. Seeding when snow is on the ground should be avoided because it reduces seed-to-soil contact and exposes the seed to predation. During this period, the prescribed native cool season species will establish; however, warm season grasses and forbs will germinate in the spring when soil temperatures rise. Dormant seeding enables cold stratification of the seed and allows the seed the earliest germination possible going into the live seeding period.

Live or spring seeding: “Live seeding” takes place when soil temperatures are consistently above 55 degrees Fahrenheit, and seed can actively germinate without the risk of a hard freeze. In the project region, live seeding is recommended between April 15 and May 30. Planting after late May is not recommended because the establishment period is a minimum of 120 days after germination. Arid and/or drought conditions in the summer months may prevent seeds from becoming established. Supplemental irrigation is recommended for Live seeding.

Disturbed areas outside the permanent seeding dates specified must be stabilized with a temporary seed mix until the permanent stabilization mix can be applied. Permanent seeding mixes shall be implemented in this area during the earliest appropriate seeding window. The Contractor shall apply temporary cover crop to all disturbed areas within 14 days of disturbance.

Weather forecasts should be monitored as supplemental watering may be necessary during prolonged dry periods. The seeding sequence should begin within 48 hours after soil preparation to capitalize on existing soil moisture prior to surficial drying. Site stabilization techniques should be used in this 48-hour period. All disturbed areas shall be stabilized no later than 14 calendar days from the date of disturbance in accordance with the standard for permanent construction area plantings.

SITE PREPARATION

Remove the gravel material using grading equipment or shovels, taking care not to disturb the geotextile fabric underneath.

Roll up or fold the geotextile fabric in manageable sections, starting from one edge of the installation area and working towards the opposite edge.

Store the removed geotextile fabric and gravel material in designated areas for disposal or reuse as appropriate.

Install the temporary irrigation system according to the specifications and the design plan sheet.

If pertinent, topsoil should be replaced or generated from on-site earthwork. The importation of topsoil should be a last resort and only used as an amendment for “localized” spots that lack the characteristics of a soil seed bed. The topsoil depth should be a minimum of 4 inches spread across the disturbance area.

Treat the disturbed area for weeds using herbicide and/or mechanical removal methods. If using herbicide treatment, the chemical compound should be approved by SLCDPU prior to use and be completed a minimum of 2 months in advance of seeding. The application should be in accordance with the product label and instructions.

Immediately prior to seeding, use a disk or harrow to run across the land, effectively breaking up the compacted soil surface to facilitate seed germination. Ensure that the equipment is properly sized and adjusted to achieve the desired depth of soil disturbance.

Operate the disk or harrow at an appropriate speed to effectively loosen the soil without causing excessive disruption or compaction of the soil structure. The soil should be scarified to maximum depth of 3 inches. Apply seed within 24 hours after seed bed preparation.

SEED APPLICATION

Ensure all components of the disc or drill seeder are clean, lubricated, and in good working condition. Check for any damage or wear on discs, openers, and closing wheels, and replace if necessary.

Calibrate the seeder according to the seed type and desired planting rate. Appropriate seed rates for the prescribed seed mix are specified on the design plan sheet.

Adjust the depth control mechanism to the desired planting depth based on soil conditions and seed type. The seeds should be sown into the soil 1/8–inch to ¼–inch depth maximum.

Fill the seed hopper with the prescribed seed mix and amount of seed. Make sure the seed hopper is clean and remove any debris or foreign materials before loading the seed.

Adjust the seeder settings to control the depth at which the seed will be planted and the spacing between seeds. Refer to the equipment manual for specific instructions on how to adjust these settings.

Install the seeder according to the manufacturer's instructions. Make sure the seed disk is securely attached and aligned with the seed metering mechanism.

Drive across the field at a consistent speed. As the seed disk rotates, seeds are picked up from the seed hopper and deposited into furrows created by the seed opener discs or tubes. Continue planting until the entire disturbance area is seeded, making sure to overlap the seed rows slightly to ensure complete coverage.

Water the area immediately after seeding. Monitor soil moisture levels and adjust watering practices accordingly. Avoid waterlogging the seed. Saturating the soil may cause seeds to float or be displaced, leading to uneven seed distribution and poor germination. This is especially problematic in soils with poor drainage.

IRRIGATION

Obtain licensed contractor and designer to provide temporary irrigation for the establishment periord.

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SECTION 32 93 10

LANDSCAPE PLANTING

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. Before submitting a Bid, each Contractor shall carefully examine the Contract Documents; shall visit the site of the Work; shall fully inform themselves as to all existing conditions and limitations; and shall include in the Bid the cost of all items required by the Contract Documents. If the Contractor observes that portions of the Contract Documents are at variance with applicable laws, building codes, rules, regulations, or contain obvious erroneous or uncoordinated information, notify the Project Manager in writing of unsatisfactory conditions. Do not proceed until conditions have been corrected.

B. Landscaping Work shall be suspended at any time when it may be subject to damage by climatic conditions. However, no substantial work suspension may be made without permission of the Project Manager.

C. Visit the site and become familiar with all existing conditions and the extent of work being performed by other contractors on the site.

D. The work covered by this section of the specifications consists in furnishing all plant material, labor, materials, and equipment; and, in performing all operations in connection with the installation of landscaping in strict accordance with this section of the specifications and the applicable drawings.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following:
   1. Trees
   2. Shrubs
   3. Mulch
   4. Topsoil
   5. Landscape Accent Boulder
   6.

B. The Section cross references the following sections:
   1. Division 1 Section "Definitions and Standards"
   2. Division 1 Section "Submittals"
   3. Division 1 Section "Closeout Procedures"
   4. Division 32 Section "Landscape Irrigation Systems"

1.04 DEFINITIONS

A. Balled and Burlaped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum laced as recommended by ANSI Z60.1.

B. Balled and Potted Stock: Exterior plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of exterior plant required.

C. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

D. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted exterior plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of exterior plant.

E. Finish Grade: Elevation of finished surface of mulch.

F. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

G. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

H. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

1.05 SUBMITTALS

A. At least 30 days prior to ordering materials, the Contractor shall submit to the Landscape Architect representative samples, certifications, manufacturer's literature, and certified test results for all materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and stamped approved by the Landscape Architect. Delivered materials shall match the approved samples.

B. Approval shall not constitute final acceptance. The Landscape Architect reserves the right to reject, on or after delivery, any material that does not meet these Specifications.

C. Product Data: For each type of product indicated.
   1. Topsoil Borrow
   2. Organic Compost
   3. Fertilizer
   4. Mulches

D. Samples for Verification: For each of the following:
   1. 1-lb. sample of bark mulch, identifying source, including name and telephone number of suppliers, and analysis testing results based on Handout “B”.
   2. Sample topsoil borrow and soil analysis testing results based on Handout “B”.
   3. Sample of organic compost and sieve analysis.
   4. Peat Moss.

E. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:
   1. Manufacturer's certified analysis for standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

F. Qualification Data: For landscape installer.

G. Planting Schedule: Indicating anticipated planting dates for exterior plants.

H. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants 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 the successful establishment of exterior plants.
   1. Installer's Field Supervision: Installer shall maintain an experienced full-time supervisor on Project site when exterior planting is in progress.
   2. Qualification of Arborist: All work of pruning shall be performed by an arborist certified by the International Society of Arboriculture.
   3. All work shall be performed in accordance with the best standards of practice relating to the trade and under the continuous supervision of a competent foreman capable of interpreting the Drawing and Specifications.

B. The following standards apply to the work for topsoil borrow:
   1. AOAC: Association of Official Agricultural Chemists.
   2. ASA: Methods of Soils Analysis, American Society of Agronomy, Soil Science Society of America, Inc., Madison Wisconsin, latest edition.
   3. American Society for Testing and Materials (ASTM).
   4. All applicable local codes and regulations.
   5. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
   6. Topsoil Analysis: Furnish a soil analysis for each planting soil mix specified in this section by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

7. Report suitability of topsoil for lawn growth. The state recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

C. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."

D. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure the main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

E. Observation:
   1. Landscape Architect shall observe trees and shrubs at place of growth and at site before planting for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site. Cost of replacements shall be borne by the Contractor.

F. Owner observation: All planting areas shall be inspected by the Owner's Representative prior to placing topsoil and amendments. All trees shall be inspected by the Owner's Representative prior to planting.

G. Selection: Contractor shall locate plant material sources and ensure plants are shipped in a timely fashion for installation. Landscape Architect shall inspect and tag plants at place of growth prior to delivery to site. Contractor to incur costs for Landscape Architect to inspect and tag plants at place of growth prior to delivery to site.
   1. At least one month prior to the expected planting date, the Contractor shall request that the Landscape Architect provide a representative to select and tag nursery stock to be planted under this Section. Contractor shall pay for the transportation, subsistence, and overnight accommodations, for the Landscape Architect's representative during the period required to select and tag the plant material.
   2. The contractor shall be responsible for certifying the availability of quality plants in specified sizes from his/her sources of supply prior to requesting that the Landscape Architect make plant source inspections. In the event that plants at the inspection location are found to be unavailable or of insufficient size, and quality, the Contractor shall be liable to reimburse the Owner for all costs of the Landscape Architect's hourly services incurred during unproductive inspection trips.
   3. Unless specifically designated otherwise, a representative of the Contractor shall accompany the Landscape Architect on plant material selection field trips.
   4. All trees for the project shall be individually tagged for approval with the Landscape Architect's seals, and no trees shall be accepted for delivery to the site without such seals.
   5. All plants procured for this project are to be tagged by the supplier nursery with the identification labels consistent with the specified plant names and project drawing identifiers if drawing symbol identifiers are used.

6. Unauthorized substitutions will not be accepted. If proof is submitted that specific plants or plant sizes are unobtainable, written substitution requests will be considered for the nearest equivalent plant or size. All substitution requests must be made in writing.

H. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.07 DELIVERY, STORAGE, AND HANDLING

A. Notify Landscape Architect 3 working days prior to the proposed arrival of plant material on site.

B. Plant materials shall be examined by Landscape Architect at time of delivery on site. This inspection does not constitute final acceptance of plants. All plants will be inspected again at time of final inspection and once again at the end of the warranty period. Any plant found to be unacceptable at any of these inspections shall be immediately removed and replaced.

C. Do not prune trees and shrubs before delivery, except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, 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 exterior plants during delivery. Do not drop exterior plants during delivery.

D. Handle planting stock by root ball.

E. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in shade, protect from weather and mechanical damage, and keep roots moist.
   1. Set nursery stock on ground and cover roots with mulch.
   2. Do not remove container-grown stock from containers before time of planting.
   3. Water root systems of exterior plants stored on-site as often as necessary to maintain root systems in a moist condition.

1.08 COORDINATION

A. Planting Restrictions: Plant during the following period. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion. March 15 to October 31.

B. Weather Limitations: Planting shall not take place when the ground is frozen.

C. Coordination with Lawns: Plant trees and shrubs after finish grades are established and before planting lawns, unless otherwise acceptable to Landscape Architect.

1.09 WARRANTY

A. All plants will be inspected at the time of final inspection for conformance to specified planting procedures, and for general appearance and vitality. Any plant not approved by the Project Manager will be rejected and replaced immediately.

B. The Contractor shall water the plantings, maintain the irrigation system, and maintain all plants at the work site until the Owner accepts the Work at the Final Inspection or Substantial Completion Inspection, whichever occurs first.

C. A Substantial Completion Certificate will only be issued for the "landscape and irrigation projects," in their entirety. Substantial Completion will not be portioned to designated areas of a project.

D. Special Warranty: The contractor shall be required to guarantee all work and plant material for a minimum of one year after the date of substantial completion. The contractor will be required to accompany the Owner's Representative on an onsite inspection just prior to the conclusion of the guarantee period. Any plant not alive, in poor health, or in poor condition at the end of the guarantee period will be replaced immediately. All replaced plants shall be guaranteed and maintained according to the specifications for another four growing months.

E. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.

F. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

PART 2 PRODUCTS

2.01 TREE AND SHRUB MATERIAL

A. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Grade: Provide trees and shrubs of sizes and grades complying with ANSI Z60.1 for type of trees and shrubs required.

C. Size and Planting Condition: As indicated on Drawings.

D. Label each tree and shrub with securely attached waterproof tag bearing legible designation of botanical and common name. Remove tags after substantial completion.

2.02 SHADE AND FLOWERING TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.

B. Small Ornamental Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as indicated on Drawings.

C. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as indicated on Drawings.

2.03 DECIDUOUS SHRUBS

A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.

2.04 CONIFEROUS EVERGREENS

A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

2.05 BROADLEAF EVERGREENS

A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

2.06 GROUND COVER PLANTS

A. Ground Cover: Provide ground cover of species indicated, established, and well rooted in pots or similar containers, and complying with ANSI Z60.1.

2.07 PLANTS

A. Perennials: Provide healthy, field-grown plants from a commercial nursery, of container size, species and variety shown or listed.

B. Fast-Growing Vines: Provide vines of container size and species indicated complying with requirements in ANSI Z60.1.

C. Bulbs: Provide large, firm bulbs of type and variety listed.

D. Pre-purchase or contract grow
   1. Perennials: Pre-purchase or contract grow healthy, field-grown plants from a commercial nursery, of container size, species and variety shown or listed.
   2. Ornamental Grasses: Pre-purchase or contract grow healthy, field-grown plants from a commercial nursery, of container size, species and variety shown or listed.

2.08 TOPSOIL BORROW

A. Refer to Section 32 93 00 Handout “B” for “Topsoil Quality Guidelines”, “Coarse Fragment Guidelines”, and “Nutrient Guidelines” for standards. Topsoil borrow shall meet all specifications for either “Ideal” or “Acceptable” categories. Topsoil that falls within the “Not-Acceptable” range shall not be used.

B. Fertilizer and additives shall be determined by the Topsoil Analysis and based on Section 32 93 00 Handout “B” for “Topsoil Quality Guidelines”, “Coarse Fragment Guidelines”, and “Nutrient Guidelines” for standards.

C. Topsoil shall consist of natural sandy loam and be of uniform quality, free from subsoil, hard clods, stiff clay, hard-pan, sod, partially disintegrated debris, or any other undesirable material. Soil shall be free of plants, roots, or seeds that would be toxic or harmful to growth. Topsoil shall be obtained from naturally drained areas and shall contain at least 4 percent organic material as determined by loss upon ignition of a moisture free sample that has been dried in accordance with current methods of the Association of Official Agricultural Chemists. Ph range shall be 5.5 to 8.2 inclusive. Subsoil will not be accepted as topsoil.

D. The Contractor shall furnish a certified report of an analytical chemist approved by the Project Manager showing the analysis of the topsoil proposed for use. Furnish a sample of the proposed topsoil to the Project Manager prior to delivery of topsoil on site.

E. No topsoil borrow shall be delivered to the site until topsoil borrow test results and recommendations have been reviewed and approved by the Landscape Architect. Such approval shall not constitute final acceptance. The Landscape Architect shall reject any material delivered to the site, which, after on-site, post-delivery testing, does not meet these specifications.

2.09 INORGANIC SOIL AMENDMENTS

A. Sulfur: Type and rate as recommended in soil reports from a qualified soil-testing agency

B. Sand: Clean, washed, natural or manufactured, free of toxic materials.

2.10 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter. The contractor shall contact the project manager for the appropriate compost to use. Refer to Section 32 93 00 Handout “B” for “Compost Quality Guidelines for Landscaping” for standards. Compost shall meet all specifications for either “Ideal” or “Acceptable” categories. Compost that falls within the “Not-Acceptable” range shall not be used.

B. Compost shall not exceed 0.5 percent inert contaminants and be free of substances toxic to plantings:

Toxic Elements	Maximum Concentration (mg/kg dry weight)
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Molybdenum	75
Nickel	420
Selenium	36
Zinc	2800

C. Peat: Coir dust, reed peat, sedge peat, moss peat (fine shreds only), reed muck or sedge muck must all comply with Q-P166e, class B coarseness. pH range of 3.4 to 4.8.

2.11 PLANTING ACCESSORIES

A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.12 FERTILIZER

A. Bonemeal: Commercial, steamed, granulated; a minimum of 2 percent nitrogen and 14 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid, in amounts recommended in soil reports from a qualified soil-testing agency.

C. Commercial Fertilizer: Commercial-grade complete fertilizer, O-F-241C, type 1, grade 16-16-8, level B with guaranteed chemical analysis of contents marked on the containers.

D. Animal fertilizer shall not be used.

2.13 MULCHES

A. Rock Mulch – 1" to 3" diameter – tan in color – fractured.

B. Rock Mulch – 4" to 6" diameter – tan in color – fractured.

2.14 WEED BARRIER FABRIC

A. Weed barrier fabric shall be one of the following: "Dewitt@ Weed Barrier Pro 5, Typar #3301, “Polyspun” XL, or approved equal.

2.15 LANDSCAPE ACCENT BOULDER

A. 36” to 48” diameter and tan boulders – provide photos for approval.

PART 3 EXECUTION

3.01 OVERALL EXAMINATION

A. Landscape Contractor must examine the site conditions under which the work is to be performed and notify the Project Manager in writing of unsatisfactory conditions. Do not proceed until conditions have been corrected.

B. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected and contract operations have been completed to a point where the areas will not be disturbed.

D. All planting areas to be inspected by the Owner’s Representative prior to adding topsoil and amendments.

E. Before any planting operation begins, all plants must be inspected and approved by the Project Manager. All rejected plants will be removed from the site and replaced with approved plants. This inspection does not waive any guarantee to be furnished by the Contractor.

F. The Landscape Contractor must coordinate with all other trades working on site to best facilitate progress on the job.

3.02 OVERALL PREPARATION

A. Locate all underground utilities prior to digging. Do not place plants on or near utility lines. Obtain a digging permit and have the permit at the site.

B. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

C. Provide 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.

D. The Landscape Contractor is responsible for finish grade elevations in landscaped areas which include topsoil shrub and turf areas, refer to Drawings for depths. Apply mulch as indicated on the Drawings in shrub beds and at base of trees. Do not bury small plants with bark mulch.

3.03 TREE, SHRUB, GROUNDCOVERS, AND PLANT BED ESTABLISHMENT

A. Review the exact locations of all trees and shrubs with the Project Manager for approval prior to the digging of any holes. Refer to the drawings for the sizes and preparation of tree and shrub holes. Prepare all holes according to the details on the drawings.

B. To avoid a soil water interface problem, excavated soil material from planting holes is to be inspected by the Project Manager to determine if such soil should be used as backfill material. If it is determined that the excavated material is not of good quality, then it should be modified to an acceptable texture, organic content and PH.

C. Prior to the installing of any plant material in the prepared hole, the Project Manager must approve the size, width, and depth of the hole.

D. Sub grades:
   1. The surface shall be free of all materials larger than 1/2" in diameter. Remove stones larger than 1/2 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   2. Scarify and pulverize the subgrade to a depth of not less than 4 inches.
   3. Mix layered soils. First place a 2–3-inch layer of the new soil, mix thoroughly with the existing soil and spread planting soil mix over loosened subgrade to depth indicated on Drawings.
   4. Scarification shall be completed in all areas that are to receive plant materials whether it is to be trees, ground cover, or shrubs.

E. Finish Grading:
   1. Finish grades shall be smooth, even and on a uniform plane with loose, uniformly fine texture. The finish grade shall not vary more than one half inch (1/2") in ten feet (10') from the required line, and grade set forth in the Drawings.
   2. Adjustments of finish grades shall be made at direction of Landscape Architect as required. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.
   3. Finish grade (top of rock and bark mulch) shrub bed areas shall be 1 1/2 inches below finish grades of adjacent pavement.

F. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.04 TREE AND SHRUB PLANTING OPERATION

A. Before planting, locate all underground utilities prior to digging. Do not place plants on or near utility lines. Obtain a digging permit first (3.01 B of this section) and have the permit at the site.

B. The planting hole should be the same depth as the root ball, and three times the diameter of the root ball. See Section 32 93 10 "Soil Preparation and Fine Grading" for Handout "A", Steps for Planting a Tree.

C. Trees and shrubs must be placed on undisturbed soil at the bottom of the planting hole.

D. The tree hole depth shall be determined so that the tree may be set slightly high of finish grade, 1" to 2" above the base of the trunk flare, using the top of the root ball as a guide.

E. EXCEPT IN RARE CASES TREES SHOULD NOT BE STAKED.

F. Set tree on soil and remove ALL burlap, wire baskets, twine, wrappings, etc. before beginning any backfilling operations. Do not fold and leave in hole.

G. Hand water all plant material in pot and when planted.

H. All tree holes shall be backfilled in 12-inch lifts and settled with water to minimize any settling of the tree.

I. Upon completion of backfilling operation, thoroughly water the tree to completely settle the soil and fill any voids that may have occurred. Use a watering hose, not the area irrigation system. If additional prepared topsoil mixture needs to be added, it should be a coarser mix as required to establish finish grade as indicated on drawings.

J. The amount of pruning shall be limited to the minimum necessary to remove dead or injured twigs and branches. All cuts, scars and bruises shall be properly treated according to the direction of the Project Manager. Proper pruning techniques shall be used. Do NOT leave stubs and do NOT cut the leader branch. Improper pruning shall be cause for rejection of the plant material.

K. Prepare a watering circle of 2' diameter around the trunk. For conifers, extend the watering well to the drip line of the tree canopy. Place 4" of mulch around the planted trees.

3.05 TREE, SHRUB, GROUNDCOVERS, AND PLANT MAINTENANCE

A. Trees, Shrubs, Groundcovers, and Plants: The Contractor is responsible to maintain all planted materials in a healthy and growing condition for a period of any four (4) consecutive growing months (growing months to be defined as April, May, June, July, August and September). This maintenance is to include weeding, cultivating, fertilizing, monitoring water schedules, controlling insects and diseases, re-guying and staking, and all other operations of care necessary for the promotion of root growth and plant life so that all plants are in a condition satisfactory to the Owner's Representative at the end of the guarantee period. The Contractor shall be held responsible for the failure to monitor watering operations and shall replace any and all plant material that is lost due to the improper application of water.

B. The Contractor shall instruct and inform the owner as to the watering and feeding requirements for each portion of the project.

3.06 PLANTING BED MULCHING

A. Upon completion of all planting operations, The Contractor is to remove all undesirable material from the surface of the planting beds, including all rocks over the size of 1/2 inch diameter; re-establish all watering basins and install the specified mulch as indicated on the Drawings. Mulch shall be placed in the planting areas as shown, spread carefully and evenly. Do not bury small plants with mulch.

3.07 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent paving and construction clean and work area in an orderly condition. The Contractor shall keep the site free from accumulation of waste material.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

C. At the time of completion, all areas must be swept or washed clean, and all rubbish removed to the satisfaction of the Project Manager.

3.08 DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

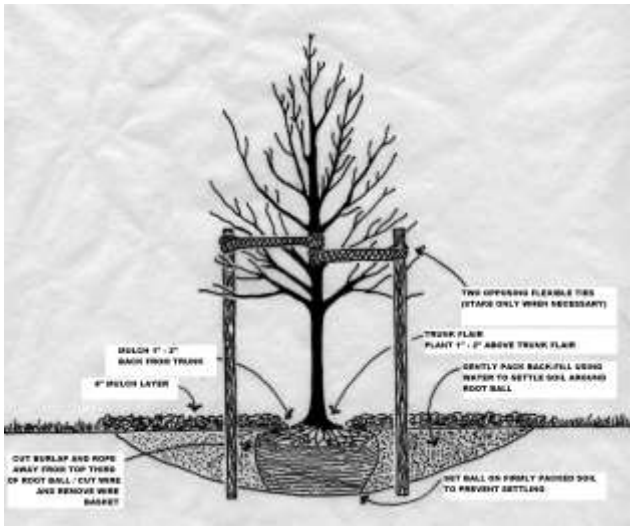
3.09 AS-BUILT DRAWINGS

A. The Contractor is required to keep a record of all departures from the working drawings that occur during construction. These shall be kept on a clean set of prints and all modifications should be noted in a clear, concise manner. The AS-BUILT DRAWINGS maintained by the Contractor shall be furnished to the Project Manager at or before the time of the Systems Inspection / Substantial Completion Inspection. The Substantial Completion Certificate Date will not be issued until the Project Manager receives the as-built record.

HANDOUT “A”

STEPS FOR PLANTING A TREE

Developed by the International Society of Arboriculture (ISA)



A. Dig a shallow, broad planting hole.

A. Make the hole wide, as much as three times the diameter of the root ball, but only as deep as the root ball.

B. Identify the trunk flare.

C. The trunk flare is where the roots spread at the base of the tree. This point should be partially visible after the tree has been planted (see diagram). If the trunk flare is not partially visible, remove some soil from the top of the root ball. Find the trunk flare to determine how deep the hole needs to be for proper planting.

D. Place the tree at the proper height.

E. Before placing the tree in the hole, check to see that the hole has been dug to the proper depth, and not more. It is better to plant the tree a little high, 1" to 2" above the base of the trunk flare, than to plant it at or below the original growing level. This will allow for some settling (see diagram). Always lift the tree by the root ball, and never by the trunk to avoid damage when setting the tree in the hole.

F. Straighten the tree in the hole.

G. Before backfilling, ask an assistant to view the tree from several directions to confirm the tree is straight.

H. Fill the hole gently but firmly.

I. Fill the hole about 1/3 full and gently but firmly pack the soil around the base of the root ball. Then, if the tree is balled and burlapped (or contained in a wire basket), cut and remove the rope, string, wire, and or wire basket from around the trunk and top 1/3 of the root ball (see diagram). Use care not to damage the trunk or roots in the process.

J. Fill the remainder of the hole, firmly packing the soil to eliminate air pockets that may cause roots to dry out. To avoid this problem, add the soil a few inches at a time and settle with water. Continue this process until the hole is filled and the tree is firmly planted. Do not apply fertilizer at time of planting unless approved by the Grounds Department.

K. Stake the tree, if necessary.

L. Except in rare cases trees should not be staked. However, protective staking may be required on sites where lawn mower damage, vandalism, or windy conditions are concerns. If staking is necessary for support, two stakes used in conjunction with a wide flexible tie material will hold the tree upright, provide flexibility, and minimize injury to the trunk (see diagram).

M. Mulch the base of the tree.

N. Apply a four inch layer. Do not cover the actual trunk of the tree. A mulch free area, one to two inches wide at the base of the tree is sufficient to avoid moist bark conditions and prevent decay.

O. Follow-up care. Keep the soil moist, but not soaked.

HANDOUT "B"

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(801) 423-1116 FAX (801) 423-1813

TOPSOIL QUALITY GUIDELINES*								
Category	**pH**	**Soluble Salts dS/m or mmho/cm**	**Sodium Absorption Ratio (SAR)**	**Organic Matter %**	**Sand %**	**Silt %**	**Clay %**	**Texture Class**
Ideal	5.5 - 7.5	<2	<3	>2.0	<70	<70	<30	Loam (L), Silt Loam (SiL)
Acceptable	5.0 - 8.2	<4	3 to 7 Sil, SiCL, CL 3 to 10 SCL, SL, L	≥1.0	<70	<70	<30	Sandy Clay Loam (SCL) Sandy Loam (SL) Clay Loam (CL) Silty Clay Loam (SiCL)
Unacceptable	<5.0 >8.2	>4	>10	<1.0	>70	>70	>30	Loamy Sand (LS) Sandy Clay (SC) Silty Clay (SiC) Sand (S), Silt (S), Clay (C)

COARSE FRAGMENT GUIDELINES*			NUTRIENT GUIDELINES FOR LANDSCAPING*				
Category	**% Coarse Fragments (Rocks) >2mm**	**≥1.5" diameter**	**Category**	**Nitrate Nitrogen ppm**	**Phosphorus ppm**	**Potassium ppm**	**Iron ppm**
Ideal	≤2.0	None	Acceptable	>20	>15	>150	>10
Acceptable	2.1 - 5.0	None	----	----	----	----	----
Unacceptable	>5.0	Present	----	----	----	----	----

**From "Topsoil Quality Guidelines for Landscaping", June 2002, AG/SO-02, prepared by Dr. Rich Koenig, Utah State University Cooperative Extension Soil Specialist, and Von Isaman, President of QA Consulting and Testing, LLC.*

COMPOST QUALITY GUIDELINES FOR LANDSCAPING*†						
Category	**pH**	**SolubleSalts dS/m or mmho/cm†**	**Sodium Absorption Ratio(SAR)**	**Carbon : Nitrogen Ratio (C:N)**	**% Moisture**	**≥98% Course Material Passing (Dry weight basis)**
Ideal	6 to 8	<5‡	<10	≤20:1	25 to 35	3/8" (9.5mm)
Acceptable	5 - 6, 8 - 9	≤10‡	<20	21:1 to 30:1	<25, >35	3/4" (19mm)
Suspect	<5, >9	>10‡	>20	<10:1, >30:1	<20, >50	<98% 3/4" (19mm)

†Compost from biosolid feedstock must meet EPA 503 Class A Standard

‡Based on 1:5 Slurry (1 part compost to 5 parts water)

**Von Isaman, President of QA Consulting and Testing, LLC, Dr. Rich Koenig, USU Cooperative Extension Soils Specialist, and Teresa Cerny, USU Cooperative Extension Horticulturist, March 3, 2003. Draft Guidelines.*

END OF SECTION

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SECTION 33 01 30.50

BYPASS PIPING AND PUMPING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This section describes the existing conditions for temporary bypass piping and pumping during construction.

B. Requirements:

1. Contractor shall provide labor, materials, and supervision to temporarily bypass flow around the Contractor's work in accordance with the specific needs construction. All references to the bypass piping, pumping and/or bypass pumping system include, but are not limited to, all pumps, piping, valves and other equipment needed to move the intended flow from one location to another.
2. The actual design of the bypass arrangement and alignment shall be prepared by the Contractor, and shall be submitted to the Engineer to determine conformance to project objectives. Means and methods of accomplishing the bypassing shall be the responsibility of the Contractor.
3. Designated yard piping shall remain in service at all times throughout the duration of the project. Contractor shall be responsible for diverting flow through the use of bypass pumping or flow diversions with prior written approval by the Engineer.
4. Service to laterals shall be disrupted for a period of no more than 8 hours. Laterals within residential areas shall only be out of service between the hours of 8:00 am to 5:00 pm, Monday through Friday. Laterals within business areas shall be addressed on a case by case basis. If Contractor feels that it is necessary to disrupt lateral services for a period longer than 8 hours, Contractor shall provide alternate means of service without disrupting use of the service by the owner/resident.
5. The bypass pumping system shall be designed to normally maintain the water flow below the top of the pipe, without surcharging.
6. The Contractor shall have the complete bypassing system in place and successfully pressure tested at 1.5 times the maximum operating pressure of the system before bypassing any water.
7. The Contractor shall notify the Engineer 48 hours prior to shutting down or bypassing the pipeline.
8. The bypassed flow shall be continuously monitored.
9. Contractor is responsible for immediate and proper cleanup should any spill occur, regardless of amount.

C. Experience: Contractor shall utilize staff and/or a subcontractor that has been directly responsible for completion of a project that required the bypass pumping of flows in excess of 4.4 mgd.

1.02 SUBMITTALS

A. The Contractor shall submit, in accordance with Section 01 33 00, drawings and complete design data showing methods and equipment he proposes to utilize in bypassing for approval by the Engineer. The submittal shall include the following information:
   1. Drawings indicating the scheme and location of temporary plugs and bypass discharge lines. The drawings shall also show the method and location for discharging the bypass lines.
   2. Capacities of pumps, prime movers, and standby equipment.
   3. Design calculations proving adequacy of the system and selected equipment.
   4. Standby power source.
   5. Staffing plan.
   6. Show suction and discharge points with elevations & stationing on the design plans.
   7. Provide pump performance curves.
   8. Submit calculations to verify suction lift of pumps has not been exceeded.
   9. Contractor shall submit proposed noise control and exhaust control plans for pumping equipment.
   10. Contractor shall submit bypass piping inspection plan.

B. The actual design of the bypass arrangement shall be prepared by the Contractor or Subcontractor performing the work, and shall be submitted to the Engineer to determine conformance to project objectives. The Contractor shall be responsible for any Subcontractors design (if used) on this Project. Means and methods of accomplishing the bypassing shall be the responsibility of the Contractor.

C. Approval of submitted plans for connection and temporary rerouting shall in no way relieve the Contractor of their responsibility for the protection of, downstream drainage systems and water tributaries against spill. Any litigation, claims, fines, etc. associated with any spill shall be the responsibility of the Contractor.

1.03 JOB CONDITIONS

A. Available Flow Data:
   1. Available flow data for yard piping to be bypassed at the project site is located in Section 01 12 16 Work Sequence and Restrictions.

B. Protection:
   1. In areas where flows are bypassed, all bypass flows shall be discharged as approved by the Engineer. No bypassing to the ground surface, receiving waters, storm drains, or bypassing which results in soil or groundwater contamination or any potential health hazards shall be permitted.

C. Scheduling:
   1. The bypassing system shall not be shut down between shifts, on holidays or weekends, or during work stoppages without written permission from the Engineer. The bypass system will have an attendant around the clock whose only duty is to maintain the bypass pumping system until the bypassing of that specific pipeline is no longer required.

PART 2 PRODUCTS

2.01 PUMPING SYSTEMS

A. Two different bypass pumping system criteria have been identified for this project. These criteria are identified below. Projects that are in environmentally sensitive areas or that have a high sewage flows will require one or more of these criteria as specified herein.

B. Criterion 1 - Bypass Pumping System with flows equal to or less than 2.5 MGD
   1. Contractor shall maintain on site, the following minimum requirements for all bypass pumping systems:
      a. Sufficient equipment and materials to ensure continuous and successful operation of the bypass systems. The COMPLETE bypass system, including all piping, shall be continuously monitored by Contractor personnel.
      b. A system of pumps and piping operating on site to maintain a minimum 50% over capacity of the anticipated maximum flow (as determined by the Contractor). In addition, the Contractor shall have a standby pump, equal in capacity to the largest pump in the system, piped, plumbed and ready for operation. Standby pumps shall be fueled and operational at all times.
      c. The Contractor shall maintain on site a sufficient number of valves, tees, elbows, connections, tools, sewer plugs, piping, hoses and other parts of system hardware to ensure immediate repair or modification of any part of the system as necessary.

C. Criterion 2 - Bypass Pumping System with flows greater than 2.5 MGD
   1. In addition to the requirements identified under Criterion 1, Contractor shall design construct, operate and maintain the bypass system specified herein:
      a. All bypass piping shall be fused HDPE piping.
      b. The bypass piping system shall include multiple pipelines to convey 150% of the maximum anticipated flow (as determined by the Contractor). A minimum of one additional (spare) pipeline will be constructed and plumbed for immediate operation that is equal in diameter to the largest pipe size in use for the bypass setup. All other requirements shall be the same as identified under Criterion 1 of these specifications.

PART 3 EXECUTION

3.01 INSPECTION

A. The Contractor shall inspect the entire bypass pumping and piping system for leaks for spills on a daily basis. The Contractor shall also create an inspection log and shall enter the time of the inspections and the condition of the piping and the name of the inspector into the log for review by the Engineer.

3.02 DAMAGES

A. The Contractor shall repair, without cost to the owner, any damage that may result from his negligence, inadequate or improper installation, maintenance and operation of bypassing system, including mechanical or electrical failures.

END OF SECTION

SECTION 33 05 01

PROTECTION OF EXISTING UTILITIES

PART 1 GENERAL

1.01 REQUIREMENTS

A. This Section specifies the requirements to identify and locate (potholing) existing subsurface utilities and requirements for protection of existing utilities and improvements.

B. Electrical, telephone, fiber optic, gas, water, and sewer locations are approximations only. Dimensions and configurations shown are compiled from various sources and are not field verified. Neither the accuracy nor the completeness of information shown is guaranteed. CONTRACTOR shall verify utility locations, dimensions, and configuration prior to start of construction.

C. Existing condition of utilities is neither known nor implied. Maintain the present day functional purpose of all existing utilities regardless of the discovered state of repair and condition, unless shown to be abandoned or removed.

1.02 RELATED SECTIONS:

A. Section 02 41 00 Demolition

1.03 REFERENCES

A. This Section includes references to the following standards. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements affording the greatest protection to the OWNER shall apply as determined by the CONSTRUCTION MANGER.

Reference	Title
APWA	Standard Specifications for Municipal Public Works Construction, Prepared by Utah State Chapter of the American Public Works Association
ASCE 38-02	ASCE Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data

1.04 DEFINITIONS:

A. Definitions used in this specification are as defined in ASCE 38-02 and as follows: Utility support systems are defined as the support systems provided to secure and suspend utilities in place and in complete working order during the performance of the WORK and for extended periods as specified.

B. Maintenance is defined as monitoring and maintaining the functional purposes of all utilities and support systems affecting the WORK.

1.05 SUBMITTALS

A. Submittals in accordance with the General Conditions and Section 01 33 00.

B. Prepare and submit a Utility Protection Plan for underground utilities affected by the Work. Plan shall include but not limited to:
   1. Description of utility to be protected
   2. Potholing data showing the relationship of the proposed work to the existing utility, size, horizontal and vertical position, material and service.
   3. Work to be completed in the proximity of the utility
   4. Proposed method to protect including:
      a. Shop drawing, the method of excavation, shoring, dimensions of trench or pit, zone of influence, offset distances from critical utilities, deflections, strain/stress on facilities, and soil-bearing loads;
      b. Structural details and calculations of temporary support systems and proposed sequence of construction;
      c. Materials list and specifications of the materials proposed for the support systems.
      d. If utility can not be protected provide method to bypass and maintain service.
   5. Proposed method to verify utility is undamaged

PART 2 PRODUCTS

2.01 REPLACEMENT IN KIND

A. Except as indicated below or as specifically authorized by the CONSTRUCTION MANAGER, reconstruct utilities with new materials of the same size, type, and quality as that removed or damaged.

B. Alternatively, contractor may construct the final configuration of the replacement pipeline and provide temporary by-pass piping and pumping for testing and commissioning. At all times the existing process pipelines must be operational and maintained until final completion of the new treatment building is operational.

2.02 PARALLEL AND PERPENDICULAR UTILITY PROTECTION

A. The pipeline alignments have numerous parallel and perpendicular utilities in close proximity which may or may not lie within the CONTRACTOR'S excavation/trench zone required to complete portions of the Work. The cost of exploratory excavations, protecting, supporting, or removal and reconstruction of these facilities will be at the expense of the CONTRACTOR and included in the bid item to which the Work is appurtenant.

2.03 SUPPORT SYSTEMS

A. Support systems used are capable of maintaining the utilities in service, undamaged for the duration of the Work.

B. Plastic Foam if used, shall be polyethylene, foam cushioning material.

PART 3 EXECUTION

3.01 GENERAL

A. Replace in kind existing infrastructure, such as curbs and gutters, barricades, traffic islands, signalization, fences, signs, etc., that are cut, removed, damaged, or otherwise disturbed by the construction.

B. Replace in kind manhole/structure components removed for bypassing or construct replacement infrastructure.

C. Before beginning pipeline excavation, determine the true location and depth of utilities and service connections which may be affected by or affect the Work. Determine the type, material, and condition of these utilities. To provide sufficient lead time to resolve unforeseen conflicts, order materials and take appropriate measures to ensure that there is no delay in Work

1. If a conflict exists between drawings and field information, notify CONSTRUCTION MANAGER immediately.

3.02 PROCEDURES

A. Protection in Place: Protect utilities in place, unless abandoned, and maintain the utility in service, unless otherwise specified on the plans or in the Specifications.

B. Remove and Reconstruct: Where so indicated on the plans or as required by the CONSTRUCTION MANAGER, remove the utility and after passage, reconstruct it with new materials. Provide temporary service for the disconnected utilities or as directed by the utility owner.

3.03 INSTALLATION

A. Perform excavation around the utilities and installation of the support systems without damage to utilities. Maintain the utility systems during the period of the WORK. Upon completion of the WORK, the utility systems are in a condition equal to or better than the preconstruction condition and operate as prior to construction.

B. Provide access to utilities for the purpose of operating and verifying the condition of their respective facilities.

C. Notify affected utility and CONSTRUCTION MANAGER of any damage to facilities immediately. Subsequent to repair, condition of the facility is equal to or better than condition of the facility prior to damage.

D. Notify affected utility and CONSTRUCTION MANAGER in the event that the existing state of repair of the utility is deemed unsafe or otherwise precludes proper support.

E. Modification to Utility Support Systems: Notify CONSTRUCTION MANAGER if the condition or location of the facility to be supported in place will require a modification to the support system as initially proposed or installed. Coordinate the revised support system through the CONSTRUCTION MANAGER.

F. Arrange and facilitate a meeting at the site with the CONSTRUCTION MANAGER and respective utility representatives for the utilities to be affected by the WORK at least 7 days prior to WORK in the vicinity of the specific utility unless otherwise specified. Be prepared to discuss the proposed utility protection measures as described in the Utility Protection Plan. Incorporate modifications to the plan resulting from the site meeting into the plan and resubmit to the CONSTRUCTION MANAGER at least five days prior to commencing the WORK in the vicinity of the specific utility.

G. Gas Facilities, Telephone, Electrical, and Fiber Optic Facilities: Protect and support in place.

3.04 BACKFILL AND COMPACTION

A. Utilities Protection in Place: After completing the Work and during trench zone backfill, backfill and compact under and around the utility so that no voids are left. Backfill around utilities shall be as shown and specified in the CONTRACT DOCUMENTS.

3.05 SERVICE LATERALS AND CONNECTIONS

A. Service laterals and connections to the various utilities (water, sewer, gas, CATV, telephone, etc) in the vicinity of the Work are not all shown on the plans. Information shown is based on best available data.

B. The CONTRACTOR shall conduct advanced potholing to confirm existing utility location, size, depth and condition to adequately define and protect existing utilities when their presence cannot be inferred from the presence of other visible facilities, such as markers, valves, buildings, meter and junction boxes, on or adjacent to the site of the Work.

C. If the CONTRACTOR discovers utility facilities not identified in the Contract Documents or in a position different from that shown in the Contract Drawings, immediately notify in writing the CONSTRUCTION MANAGER about the utility facility.

3.06 UTILITY INTERFERENCE

A. Where existing utilities interfere with the prosecution of the Work, the CONTRACTOR, shall relocate them in accordance with the requirements of the utility owner. Relocation shall only be completed after written approval by the utility owner and/or CONSTRUCTION MANAGER is provided.

B. When it is necessary to remove, relocate, protect, or temporarily maintain a service connection, the CONTRACTOR shall bear all expenses incidental to the Work on the utility or damage thereto. The work on the utility shall be done in a manner satisfactory to the utility owner; it being understood that the owner of the utility has the option of doing such work with his own forces or permitting the work to be done by the CONTRACTOR.

END OF SECTION

SECTION 33 05 25

EXCAVATION SUPPORT SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies requirements for sheeting, shoring, and bracing of trenches greater than five (5) feet in depth. The CONTRACTOR shall provide all labor, equipment, materials, and services necessary.

B. The CONTRACTOR shall design sheeting, shoring, and bracing in accordance with OSHA safety regulations (29 CFR, Part 1926, Subpart P, Excavations) for sloping the sides of excavations, using shoring and bracing, and for using other safety features.

1.02 REFERENCES

A. This Section includes references to the following standards. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements affording the greatest protection to the OWNER shall apply, as determined by the CONSTRUCTION MANAGER.

Reference	Title
APWA	Standard Specifications for Municipal Public Works Construction, Prepared by Utah State Chapter of the American Public Works Association, latest edition.
MUTCD	Manual on Uniform Traffic Control Devices, United States Department of Transportation, Federal Highway Administration (latest edition)
OSHA	OSHA Safety Regulations (29 CFR, Part 1926, Subpart P. Excavations)
UDOT	Utah Department of Transportation (UDOT) 2017 Standard Specification and Drawings for Road and Bridge Construction

1.03 SUBMITTALS

A. Submittals in accordance with the General Conditions and Section 01 33 00.

B. Submit design calculations, shop drawings, and detail drawings that demonstrate conformity with OSHA regulations and suitability for design loads and installation methodology. The design shall be stamped and signed by a Registered Professional Engineer of the State of Utah.

C. Submit shop drawings showing dimensions, elevation, and structural details for each utilized excavation support system. Include on the drawings any required construction sequence, loading, testing, monitoring, and re-bracing/removal requirements. The design shall be stamped and signed by a Registered Professional Engineer of the State of Utah.

D. Submit excavation plans for worker protection in pipe trenches and other excavations. Submittal of excavation plans shall be for records only. Other than to verify that slide rail shoring is being used, submittals will not be reviewed by the Construction Manager as they are the sole responsibility of the Contractor and the Registered Engineer who signs and seals said plans.

E. Informational Submittals:
   1. Trench excavation plan addressing following topics:.
      a. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.
      b. Design assumptions and calculations.
      c. Methods and sequencing of installing excavation support.
      d. Proposed locations of stockpiled excavated material.
      e. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
      f. Anticipated difficulties and proposed resolutions.
   2. Movement measurement and data and reduced results indicating movement trends.
   3. The excavation support plan and the trench excavation plan shall be sealed by a professional engineer licensed in the State of Utah.
   4. Stamped Calculations

F. Action Submittals: Name and qualifications of the Professional Engineer(s) registered in the State of Utah responsible for trench excavation support design.

1.04 DESIGN REQUIREMENTS

A. Design excavation support systems to withstand earth pressures, hydrostatic pressures, bottom heave, equipment loads, applicable traffic and construction loads, and other surcharge loads to allow safe construction without movement or settlement of the ground and to prevent damage to or movement of adjacent structures, streets, and utilities. Design each member or support element with appropriate safety factors.

B. Acceptable excavation support methods include the use of trench boxes, suitable moving support systems, steel sheet pilings, soldier piles and lagging, jet grouted structures, secant pile structures, structural steel wales and struts, liner plates, and timber. If soldier piles are used, insert in predrilled holes. Horizontal strutting below the barrel of a pipe and the use of pipe as support are not acceptable.

C. Provide construction stage loadings for a staged removal of the support system that conforms to the pipe, structure placement, and indicated backfill.

D. Compaction of foundation, bedding, haunching, and backfill shall extend to the undisturbed trench wall during staged removal of the support system.

1.05 QUALITY ASSURANCE

A. Provide surveys to monitor movements of critical facilities.

B. Trench excavation support systems shall be designed by a professional engineer registered in the State of Utah who has a minimum of 5 years of experience in the design of retaining structures.

PART 2 PRODUCTS

A. Slide rail shoring may be required to protect existing buildings and utilities. Acceptable slide rail shoring suppliers include the following, or equal:
   1. GME (Griswold Machine and Engineering)
   2. Pro-Tec Equipment, Inc
   3. Efficiency Production, Inc..
   4. SHB, Double Slide Rail, Series 750.

B. Structural Steel: ASTM A36 or better, unless otherwise approved.

PART 3 EXECUTION

3.01 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

B. Before beginning construction, install, and survey monitoring points as required, adequately protect existing structures, utilities, trees, shrubs, and other existing facilities. The repair of or compensation for damage to existing facilities will be at no cost to the Owner.

C. All welding will conform to the applicable provisions of ANSI/AWS D1.1.

D. Provide, place, and maintain supports, shoring, and sheeting as may be required for sides of excavations. Support excavations in a safe manner in accordance with applicable regulatory safety requirements.

E. The construction of sheeting, shoring, and bracing shall not disturb the state of soil adjacent to the trench and below the excavation bottom.

3.02 SEQUENCE

A. Trench excavation shall not be started until the design for trench support has been accepted by the CONSTRUCTION MANAGER.

3.03 TRENCHES

A. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable local construction safety orders, and OSHA requirements.

B. At any time Contractor's personnel are not present within the immediate vicinity of the Work, open excavations shall be plated, barricaded, or fenced, as necessary, to protect the public and worker safety.

3.04 REMOVAL OF SUPPORT SYSTEM

A. Excavation support shall not be removed until support can be removed without damage to existing facilities, completed Work, or adjacent property.

B. As a minimum, excavation support shall be removed between the existing adjacent surface grade and 5 feet below the adjacent surface grade. As-built Drawings will be prepared showing location of temporary shoring and bracing that remains in place.

C. Excavation support shall be removed in a manner that will maintain support as excavation is backfilled and will not leave voids in backfill. Removal of the support system shall be performed in a manner that will not disturb the pipeline, the compacted backfill, or adjacent construction or facilities.

D. Any void left by shoring system or voids created by the removal of the shoring system will be filled with controlled low strength material (CLSM) or cement grout, as approved by the Construction Manager, to provide soil support between backfill zone and the native soil.

E. Sheet piling removal shall be performed in a manner that will not result in “vibro consolidation” of sandy or granular material below the excavation that could lead to settlement of the pipeline or other works of construction.

F. The support system removed from the excavation shall remain the property of the Contractor and shall be removed from the Site.

END OF SECTION

SECTION 33 05 31

PVC C900 PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies gasketed, solid wall polyvinyl chloride (PVC) pressure and gravity pipe, fittings, joints and service connections where specified.
   1. Construction of Plant Drains, Storm lines, Recycled Water, Potable, and Sewer shall adhere to the State of Utah Criteria for the Separation from Drinking water.

B. Provide all necessary labor, materials, equipment, and services to provide a complete, in-place PVC pipeline and to accurately locate in the field service laterals.

C. Pipe diameters specified represent nominal inside pipe diameter, unless otherwise specified. [Cast iron pipe sizes CIOD]

1.02 RELATED SECTIONS

A. Section 31 21 33 Trenching, Backfilling, and Compacting for Utilities

1.03 QUALITY ASSURANCE

A. REFERENCE: This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D883	Definitions of Terms Relating to Plastics
ASTM D1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
ASTM D2122	Method of Determining Dimensions of Thermoplastic Pipe and Fittings
ASTM D2241	Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

Reference	Title
ASTM D2444	Standard Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
ASTM D2774	Standard Practice for Underground Installation of Thermoplastic Pressure Piping
ASTM D3139	Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
ASTM F1674	Standard Test Methods for Joint Restraint Products for Use with PVC Pipe
AWWA C110	Ductile Iron and Gray-Iron Fittings
AWWA C153	Ductile Iron Compact Fittings
AWWA C605	Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 300 mm), for Water Distribution
AWWA C907	Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 Mm Through 300 Mm), For Water, Wastewater, And Reclaimed Water Service
AWWA M23	PVC Pipe - Design and Installation
[CSA B137.3	Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications.]
Plastic Pipe Institute (PPI)	PPI TR3 - Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.
PVC Pipe Association (UNI-BELL)	The Handbook of PVC Pipe Design and Installation by the Uni-Bell PVC Pipe Association. (latest edition)
PVC Pipe Association (UNI-BELL)	UNI-B-13 - Recommended Standard Performance Specification for Joint Restraint Devices for Use with Polyvinyl Chloride Pipe.

C. SHOP INSPECTION

1. The Owner’s Representative may inspect materials production and witness testing of pipes, fittings, elbows, and special pieces at the manufacturer's plant.
   a. Provide two weeks written advance notice of where and when production will commence and provide free and unlimited access to all portions of manufacturer's plant that are necessary to verify compliance with this specification. This inspection shall not replace the pipe manufacturer's own quality control procedures.

D. SHOP TESTING

1. Unless otherwise specified, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of the applicable referenced standards. Perform said material tests at no additional cost to the OWNER. The Owner’s Representative shall have the right to witness all testing.
   a. For pressure applications, each length of pipe must be hydrotested at twice the rating and a short-term pressure test must be conducted once per production run.

E. SUPPLIERS

1. Like items of pipe, joints and fittings shall be the end products of one manufacturer and shall be manufactured within 18-month period prior to installation. Pipe shall be date coded by manufacturer and the manufacturer's code provided on the pipe and delivery manifests.

F. Manufacturer Certifications:
   1. AWWA C900
   2. Factory Mutual (FM) 1612 Approved
   3. NSF Standard 14 and NSF Standard 61 listings for Potable Water Application
   4. Certification under NSF/ANSI 327 Annex G "lead-free"
   5. Underwriters Laboratories Inc. Standard 1285 mark of acceptance

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, SUBMITTAL PROCEDURES.

B. Action Submittals
   1. A copy of this specification section, with addendum updates included, and referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Informational Submittals
   1. Manufacturer’s shop drawings and catalog data with sufficient detail to show compliance with specified requirements. Shop drawings shall illustrate pipe lengths, wall thickness, pipe class, and dimension ratios (DR).
   2. Details of fittings, pipe joints, joint gasket (size and shape), service connections, saddles, their locations, and related appurtenances with locations and complete service connection detail.
   3. Pipe-to-pipe/appurtenance connection details with Manufacturer’s product data, material properties with applicable ASTM references and technical installation requirements.

D. Construction Submittals
   1. Prior to delivery of the pipe from each manufacturing lot or run:
      a. Provide an affidavit of compliance with AWWA C900 and this specification.
      b. Submit certified laboratory testing results for provided pipe.

E. Construction Submittals
   1. Cut sheets showing stationing, invert elevations, ground elevations, and cuts every [25 feet] or at connection points to manhole and structures. Surveying shall be performed under the supervision of and certified by a licensed Professional Land Surveyor of the State of [state].

F. Close out Submittals
   1. Per Section 01 78 39, PROJECT RECORD DOCUMENTS

1.05 DELIVERY, STORAGE AND HANDLING

A. Pipe shall be packaged, handled and stored in accordance with AWWA M23 and the manufacturer's recommendations. PVC pipe that has been gouged, scratched, or otherwise damaged shall be subject to rejection at the discretion of the Owner's Representative. Rejected pipe shall be removed from the site and replaced at no additional cost to the Owner.

B. Pipe shall be protected from UV radiation by covering with opaque tarpaulins until immediately prior to installation. Remove from Site all PVC pipe showing signs of physical damage or ultraviolet exposure, as determined by [Owner's Representative].

C. Inspect each pipe prior to installation. The pipe shall be free of cracks, crazing, holes, delamination, foreign inclusions, air bubbles, blisters, or other deleterious defects. Remove rejected, damaged or defective materials from Site.

D. Keep pipe and gaskets free of dirt, foreign matter, and exposure to heat, sunlight, ozone, oil, and grease. PVC pipe that has been contaminated in any way with petroleum products (on the inside or outside of the pipe) shall not be used.

1.06 WARRANTY

A. Provide Manufacturer warranty

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide pipe and fittings manufactured from virgin PVC compound meeting or exceeding cell classification of 12454 as defined by ASTM D1784 and a hydrostatic design basis rating of 4000 psi for water at 73.4 Deg F.

B. Additives and fillers, including stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed 10 parts by weight per 100 of PVC resin in the compound.

C. Color per
   1. Potable Water: Blue
   2. Sewer Water : Olive Green
   3. Recycled Water: Purple
   4. Drain/Storm Water: White

2.02 PVC PRESSURE PIPE

A. Meet or exceed the minimum DR and pressure rating as specified and meeting the requirements of AWWA C900.

B. Provide pipe in accordance with AWWA C900 with a minimum [Pressure class, dimension ratio, Cast Iron Outside Diameter (CIOD)]

C. Provide standard nominal laying lengths, 10- or 20-ft unless otherwise specified or required to achieve the pipe alignment geometry. Pipe and fittings must be circular and concentric with the pipe barrel cut off on a plane at right angle to longitudinal axis of pipe.

D. Markings: Meet the minimum requirements of AWWA C900. Minimum pipe markings shall be as follows:
   1. Manufacturer's Name or Trademark and production record
   2. Nominal pipe size
   3. ASTM Standard
   4. Cell Classification
   5. Seal of testing agency that verified the suitability of the pipe. (marked "NSF-PW-G")
   6. ["CAUTION: "NON-POTABLE" OR "RAW WATER" – DO NOT DRINK."]
   7. Homemark on the spigot end to indicate proper penetration when the joint is made.

E. Accepted pipe manufacturers:
   1. Diamond Plastics Corporation
   2. North American Pipe Co (NAPCO)
   3. JM Manufacturing Co., Inc.
   4. IPEX, Blue Brute,
   5. or equal]

2.03 DESIGN CRITERIA

A. Obtain the following information from the drawings:
   1. Elevation of the pipe invert and of the completed ground.
   2. Alignment of the pipeline.
   3. Nominal diameter.
   4. Outside Diameter Control [CIOD]
   5. Pipe Dimension Ratio
   6. Maximum allowable deflection

2.04 PVC JOINTS

A. Bell and Spigot Joints
   1. Provide integral bell joint meeting the requirements of ASTM D3139 with an elastomeric seal meeting the specification defined in ASTM F477. Ends must have the same or greater thickness as of the pipe barrel.
   2. Gaskets shall be factory-assembled and securely bonded in place to prevent displacement. [Gaskets shall be lock-in style]
   3. Lubricants shall be non-toxic, food grade and biodegradable as recommended by the manufacturer.

B. Restrained Joints

1. Provide restrained joints on all pressure pipelines via restrained push-on or restrained mechanical joint per AWWA C111 except where flanged joints are required to connect to fittings, valves, and other equipment as specified. Joint restraint shall be installed in accordance with the manufacturer's instructions.

C. Gaskets

1. Provide [SBR],[EPDM] gaskets conforming to ASTM F477: Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2.05 FITTINGS

A. PVC Fitting shall be one-piece injection molded or fabricated from PVC compounds meeting ASTM D1784 with an equal or greater pressure rating that the pipe to which the fitting is connected.

B. Fabricated fittings shall conform to AWWA C900 PVC pipe. Segments bonded together may be over-wrapped with fibreglass-reinforced polyester. The pressure class must meet or exceed the pipe.

C. Accepted fittings manufacturers:

1. GPK Products, Inc.
2. North American Pipe Co (NAPCO)
3. JM Manufacturing Co., Inc.
4. IPEX, Blue Brute,
5. Multifittings, Ltd./Ipex, Inc.]

D. DIP Fittings

1. Provide ductile-iron fittings in accordance with AWWA C110 or C1553 with a minimum rated working pressure equal or greater that the PVC pressure pipe.
2. The fittings shall match the bell size and diameter control of the provided PVC pipe including the gasket-ring retaining groove.

2.06 COUPLINGS

A. Couplings shall meet the requirements of AWWA C900 as applicable, and have a minimum rated working pressure equal or greater that the PVC pressure pipe. Deflection at the coupling shall not exceed 50% of the manufacturer's written maximum recommendation unless otherwise specified.

B. Flange Adapters

1. Provide flange adapter specifically designed for PVC Pressure pipe when connecting PVC pressure pipe to flanged fittings or flanged valves

C. Transition and Sleeve Type Couplings

1. Provide transition and sleeve-type couplings specifically designed for use with PVC pressure pipe. Devices must be restrained to prevent axial separation of connected plain end pipe or dissimilar materials.

D. Bolts and nuts for mechanical joints, or flanged ends will be of a high strength corrosion resistant low-alloy steel and shall conform to AWWA C111. Flange bolts and nuts for above ground installation shall conform to Appendix A of AWWA C115. Flange bolts and nuts for below ground installation shall be 316 stainless steel. All fittings shall be fusion bonded epoxy lined and coated and lined unless stainless steel is used.]

PART 3 EXECUTION

3.01 GENERAL

A. Make connections to different pipe materials by means of flanges, specified adapters or transition fittings. Where sleeve type couplings are used, both shall be uniformly torqued in accordance with pipe manufacturer's recommendation. Foreign material shall be removed from the pipe interior prior to assembly. Do not change the type or class of pipeline material between manhole sections.

3.02 COMPLIANCE TESTING

A. Conduct tests required in ASTM D3034, ASTM D2412, D32124, and F477.

3.03 INSTALLATION

A. Install PVC pressure pipe in accordance with ASTM D2774, AWWA M23, AWWA C605, and the manufacturer's recommendations. In the case of conflict, the stricter requirement as determined by the Owner's Representative shall apply.

B. Provide survey cut sheets with invert elevations, ground elevations, and cuts every 25 feet and lateral locations. Cut sheets shall be provided by a surveyor working under the supervision of a registered professional surveyor in the state of Utah.

C. Minimum bedding thickness shall be 6-inches unless otherwise specified.

D. Lay pipe without break, upgrade from structure to structure, with the socket ends of the pipe upgrade.

E. Do not use the pipe as a drain for removing water from the trench.

F. After joint assembly, bring the bedding material up to pipe spring line, taking care to uniformly support the pipe. Bedding material shall be imported, placed and compacted per Section 31 20 00 EARTHWORK.

G. Backfill remainder of trench per Section 31 23 00 EARTHWORK.
   1. Do not use hydro hammers to compact bedding or backfill.
   2. Do not use flooding and jetting to compact bedding or backfill.

H. Place a 2 foot PVC joint of the same inside diameter as the adjoining pipe at the inlet and outlet to each manhole or structure. Use one of the following methods:

3.04 LINE AND GRADE

A. Pipe shall not deviate more than 1 inch from line or 1/4 inch from grade. Measure for grade at the pipe invert.
   1. Corrections or changes in line or grade may not be made by pipe bending.
   2. When installed, established line shall not result in high points or bellies in the reach.

B. PVC pressure pipe shall be deflected at the joints only. The maximum allowable joint deflection shall be limited to and shall not exceed 50% of the manufacturer's recommendation or 1 degree, Whichever is less.

3.05 TESTING

A. Testing of plastic piping shall be as specified in Section 40 05 01.

END OF SECTION

SECTION 33 05 33.13

CORRUGATED-WALL, SMOOTH INTERIOR HDPE GRAVITY PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes high-density polyethylene (HDPE) pipe for stormwater and other surface water drainage, with or without end treatments such as headwalls or flared end sections.
   1. Double-wall, smooth interior polyethylene pipe manufactured for all drainage applications, including storm sewers, culverts, stormwater storage and water quality management.
   2. Related joints and accessories.

1.02 RELATED SECTIONS:

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 31 23 00: Excavation and Fill
   2. Section 31 21 33: Trenching, Backfilling, and Compacting for Buried Piping

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AASHTO M 252	Specification for Corrugated Polyethylene Pipe, 75- to 255-mm (3- to 10-inch) Diameter
AASHTO M 294	Specification for Corrugated Polyethylene Pipe, 305- to 915-mm (12- to 36-inch) Diameter
ASTM D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F2306	Standard Specification for 300 mm to 1500 mm [12 in. to 60 in.] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Non-Pressure Gravity-Flow Storm Sewer and Subsurface Drainage Applications

1.04 SUBMITTALS

A. Product Data: Submit data on pipe, fittings, and accessories.

PART 2 PRODUCTS

2.01 MATERIALS

A. Plastic Storm Drain Pipe:

1. Polyethylene Storm Pipe: AASHTO M252 or M294, or ASTM F2306, with a smooth interior and annular exterior corrugations. Manning's "n" for use in design shall be 0.012.
    a. Joints: Pipe shall be joined using a bell and spigot joint meeting the requirements of AASHTO M252, AASHTO M294,or ASTM F2306.
    b. The joint shall be soil-tight and gaskets for diameters 12- through 60-inch, shall meet the requirements of ASTM F477. For diameters 4- through 10-inch, the joint shall be soil-tight using an engaging dimple connection.
    c. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

B. Fittings:

1. Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a welded bell and valley or saddle gasket meeting the soil-tight joint performance requirements of AASHTO M252, AASHTO M294, or ASTM F2306.

C. Materials Properties:

1. Material for pipe and fitting production shall be high density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch diameters, and 435400C for 12- through 60-inch diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4 percent.
2. The 12- through 60-inch pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306, respectively.

D. Bedding and Cover Materials:

1. Bedding: Class A material as defined in Section 31 23 00.
2. Backfill: As specified in Section 31 21 33.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify existing conditions before starting Work. Notify ENGINEER when existing conditions DO NOT match Drawings.

B. Verify trench cut or excavation base is ready to receive Work and excavations, dimensions, and elevations are as shown on the Drawings.

C. Remove large stones or other hard matter that could damage piping or impede consistent backfilling or compaction.

3.02 INSTALLATION

1. Excavation and Bedding:
   a. Excavate trench in accordance with Section 31 23 00 and place bedding material in accordance with Section 31 21 33.
   b. Maintain optimum moisture content of bedding material to attain required compaction density.
2. Pipe:
   a. Installation shall be in accordance with ASTM D2321 and pipe manufacturer recommended installation guidelines.
   b. Minimum cover in trafficked areas for 4- through 48-inch diameters shall be one foot. and for 60-inch diameter the minimum cover shall be 2-feet.
   c. Lift or roll pipe into position. Do not drop or drag pipe over prepared bedding.
   d. Shore pipe to required position; retain in place until after compaction of adjacent fills.
   e. Ensure pipe remains in correct position and to required slope.
   f. Place and compact bedding and fill as described in Section 31 21 33 and Section 31 23 00.

END OF SECTION

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SECTION 40 05 01

PIPING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the general requirements for design, selection, and supply of pipe materials, fittings, appurtenances, expansion control, supports, and seismic restraints for process, mechanical, plumbing, utility, odor control ducts, and HVAC piping systems. Installation, inspection, and testing are also specified in this Section.

B. Use the general requirements specified in this section with the more specific requirements listed in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) and other referenced sections. Except where referenced specification sections specify alternate provisions, the requirements of this Section apply to all piping systems listed in Section 40 05 02.

C. Provide professional engineering services for a piping system design engineer (hereinafter and in all related and referenced sections the "Design Professional") for the design and inspection of piping systems work. For the scope of the work, defined herein as the “Design Professional’s Scope of Responsibility,” the Design Professional provides the design, final inspection, and certification for the piping supports, seismic restraints, and expansion control as specified in this Section and referenced sections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 61 45 – Area Exposure Designations
   3. Section 01 66 00 – Product Storage and Handling Requirements
   4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   5. Section 03 30 00 – Cast-in-Place Concrete
   6. Section 31 23 00 – Excavation and Fill
   7. Section 40 05 02 – Piping System Schedules
   8. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
   9. Section 40 05 07 – Hangers and Supports for Process Piping
   10. Section 40 05 07.13 – Seismic Restraints for Piping
   11. Section 40 05 07.16 – Expansion Control for Piping
   12. Section 40 05 45 – Piping System Identification
   13. Section 40 42 00 – Insulation for Exposed Piping and Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ANSI B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ANSI B31.1	Power Piping
ANSI B31.3	Process Piping
ANSI B31.9	Building Services Piping
ANSI Z223.1	National Fuel Gas Code
ANSI/ISA-S70.01	Quality Standard for Instrument Air
ASME B1.1	Unified Inch Screw Threads
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM F37	Sealability of Gasket Materials
ASTM F104	Nonmetallic Gasket Materials
ASTM F152	Tension Testing of Nonmetallic Gasket Materials
AWWA C651	Disinfecting Water Mains
CAN/CGA B149.6	Code for Digester Gas and Landfill Gas Installations
EJMA	Expansion Joint Manufacturer's Association
UPC	Uniform Plumbing Code

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Maximum pressure: The greatest continual pressure at which the piping system is designed to operate.
   2. Test pressure: The hydrostatic, air, or gas pressure used to determine system compliance.
   3. Take down coupling: Pipe couplings that facilitate disassembly of piping systems without damage or demolition of piping system components.
   4. Embedded/Encased piping: Piping enveloped in reinforced concrete, typically under structures and under roadways, where specified on the drawings.
   5. Exposed: All area exposures specified in Section 01 61 45 other than buried, submerged, or encased/embedded.

B. Piping System Identification
   1. Process, mechanical, plumbing, utility, odor control, and HVAC piping system piping is identified by a two component alpha-numeric code, (Line Label) as follows:
      a. The first component of the code indicates the nominal line size.
      b. The second component of the code identifies the process Service or fluid being conveyed in the Piping System.
   2. Process Service identifiers for pipelines are specified on the drawings. The Process Service is defined for each Process Service Identifier in Section 40 05 02.

3. Detailed specifications for each Process Service are scheduled in Section 40 05 02.00 through 40 05 02.99.
4. Mark and label Piping Systems as specified in Section 40 05 45.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Refer to Section 40 05 45 for process piping identification requirements.
2. Pipe Sleeves: Coordinate placement of sleeves and penetrations in cast-in-place concrete with raceway, duct, and pipe penetrations prior to concrete placement. Coordinate placement of sleeves and wall penetration prior to construction of masonry building elements.
3. Coordination required with the design of piping supports (hangers, guides, anchors, structural attachments, etc.), expansion joints, and expansion control and seismic restraints. Refer to sections 40 05 06.23, 40 05 07, 40 05 07.13, and 40 05 07.16.
4. Refer to paragraph 1.09 Piping System Design for additional coordination requirements.

1.06 SUBMITTALS

A. Action Submittals:
1. Procedures: Section 01 33 00.
2. Qualifications of the Design Professional charged with inspection and certification of pipe hangers and supports and related scope of work; provide educational background, proof of registration, and proof of insurance and previous experience in performing this type of work. No further submittals under this or any related section will be considered until the Design Professional's qualifications have been reviewed and accepted by the Construction Manager.
3. A copy of this specification section, along with Sections 01 73 24, 40 05 06.23, 40 05 07, 40 05 07.13 and 40 05 07.16, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. For each piping system (refer to Piping System Schedules in Section 40 05 02.00 through 40 05 02.99), submit document listing pipe, fittings, linings, coatings, valves, flexible connectors, expansion joints, couplings, bolts, gaskets, restraints, and other items provided for each applicable pipe size and category.

5. Welding: Prior to commencing any welding of steel or stainless steel pipe, supports, and/or structural attachments, provide a written description of welding techniques, including, but not limited to, materials, methods, and quality control. Identify differences in shop and field techniques. Indicate in the submittal that the welding technique has been reviewed for each piping service and certify that the technique is acceptable for the intended service condition (piping service defined in Section 40 05 02 and area exposure designation specified in Section 01 61 45). Written procedures to be stamped and sealed by a Professional Engineer registered in the State of Utah and qualified for welding design.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Pre-Construction Data:
      a. Design drawings and calculations for pipe supports, anchorage, seismic restraints, and expansion control systems as specified in Sections 40 05 07, 40 05 06.23, 40 05 07.13, and 40 05 07.16. Drawings and calculations sealed and submitted by the Design Professional specified in this Section. The Design Professional shall affirm that loads on structures are within any stipulated load limits that may be noted on the contract documents.
      b. Submit piping layout drawings for all piping systems, including raceway, duct and other specified systems support. Indicate assembly details, location and placement of field welds, unions and flanges, fittings, valves, flushing connections, drains, sample taps, cathodic protection, seismic restraint system, expansion joints, guides, anchors, hangers, supports, and the provisions for thrust restraint, as well as any other pertinent details and appurtenances for all piping, including wall and floor penetrations, where applicable, in that area. Indicate location and clearances from structures and other utilities (ductwork, conduit, electrical tray, etc.). Include details of connections to new and existing equipment, piping and structures. Submit original layouts by the Contractor; photocopies of Contract Drawings are not acceptable. Identify the invert elevation of buried pipe at changes in slope, pipe crossings, and connections to structures on piping layout drawings in addition to providing coordinates for locating changes in horizontal alignment of buried pipe.
      c. Product Samples: Where specified or when directed by the Construction Manager, provide mill test results or product samples.
      d. Prior to the commencement of welding, submit current and complete documentation of the welder's qualifications.
      e. Safety plans for pneumatic pressure testing.
   3. Post-Construction Data: Inspection reports, authored, sealed, and signed by the Design Professional retained under the provisions of this Section submitted to the Construction Manager. The Design Professional's final report shall be submitted to the Construction Manager before beneficial occupancy by the Owner.

1.07 QUALITY ASSURANCE

1. Review the drawings prior to installation of piping, conduit services, and fixtures. Identify any conflicts and cooperate with the Construction Manager to determine the adjustments necessary to resolve conflicts.
2. Confirm the routing of each section of pipeline with other services prior to commencement of installation. Advise the Construction Manager of any conflicts with existing services or services yet to be installed. Where necessary, amend the routing of pipework to avoid conflict and confirm with the Construction Manager.
3. Refer to paragraph 1.09 Piping System Design for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Requirements:
   1. Deliver pipe, fittings, and specials to site using loading methods which do not damage pipe or linings, or coatings.
   2. Piping materials delivered to site will be clearly marked to indicate size, type, class/schedule and coatings.
   3. Until ready for incorporation in the work, store on site as recommended by the piping materials manufacturer to prevent damage, undue stresses, or weathering.
   4. Store materials at least 8 inches above ground. Provide sufficient supports to prevent undue bending.
   5. Protect non-UV light inhibited plastic from sunlight.
   6. Maintain refrigerant piping factory seals until ready for incorporation into the Work.
   7. Cover openings in piping, and temporarily seal to protect from contamination.
   8. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by elevating above floor or surrounding grade.
   9. Protect unfinished work at end of each workday from damage, contamination and moisture by use of plugs, caps or covers.
   10. Protect piping and valves from damage pending performance of system tests.
   11. Use proper implements, tools, and facilities for the proper protection of the pipe. Exercise care in the installation so as to avoid damage to pipe, linings, and coatings.
   12. Inspect each pipe and fitting prior to installation. Do not install damaged pipe or pipe with damaged protective coatings or linings.
   13. Prevent entry of foreign matter during handling, assembling, and installation. Use compressed air, wire brush, solvent and other acceptable means to remove all foreign matter from inside of pipe prior to installation. Remove residual scale, dirt and other foreign matter from interior of piping before final connections are made.

1.09 PIPING SYSTEM DESIGN

A. Design Professional:
   1. Provide professional engineering services ("Design Professional") for the design and inspection of piping systems work. The Design Professional must have not less than ten years' experience in the type of piping support, seismic restraint, and expansion control design work required for this project.
   2. The Design Profession shall be a professional engineer currently licensed to practice in the State of Utah.
   3. The Design Professional must obtain and maintain professional liability insurance in the amount of $1,000,000 aggregate, to be in effect for the duration of this project plus one year.
   4. The requirements for the Design Professional shall not be construed as relieving the Contractor of overall responsibility for this portion of the work.

B. Piping System Design and Inspection:
   1. The Design Professional shall provide the design, inspection, and certification for piping supports (hangers, guides, anchors, structural attachments, etc.), expansion control and seismic restraints as specified in this Section and referenced Sections.
   2. The work of the Design Professional is complementary to the design elements specified in the Contract Documents and intended to provide complete piping system designs. The Design Professional's inspection responsibilities also complement inspections by the Construction Manager. The division of responsibility for work is shown in the following table:

Piping System Element (Specification)	Design Professional's Responsibility	Construction Manager's Responsibility
Pipe material and thickness, test pressures and other properties (Section 40 05 02.00 through 40 05 02.99)	(NA)	All piping
Contractor layout drawings (Section 40 05 01)	All piping	(NA)
Support design (Section 40 05 07 and Section 01 73 23, and related sections)	All piping, except as indicated for Construction Manager's Responsibility	Pipe supports specified on the drawings
Seismic bracing (Sections 40 05 07.13 and Section 01 73 23, and related sections)	All piping, except as indicated for Construction Manager's Responsibility	Seismic bracing specified on the drawings
Expansion and Control Design (Section 40 05 07.16 and related sections)	All piping, except as indicated for Construction Manager's Responsibility	Expansion Control provisions specified on the drawings
Inspection – General. For design and specification conformance (Section 40 05 01 and related sections)	All piping	(NA)

   3. Acceptable types of supports, guides, saddles, expansion joints, flexible couplings, hangers and structure attachments for general piping support are specified in Section 40 05 07. Seismic restraints are specified in Section 40 05 07.13. Pipe expansion control systems are specified in Section 40 05 07.16. Incorporate these specific elements into the design prepared by the Design Professional.

4. Pipe support and seismic restraint placement is subordinate to the function of anchorage, flexibility, and expansion control provisions. Do not interfere with the function of anchorage, flexibility, and expansion control provisions specified on the drawings.
5. Where pipe anchors are specified, they have been designed for longitudinal (axial) seismic loading, in addition to other longitudinal forces associated with expansion control, and pipe thrust for the associated piping. Rely on the specified anchors for longitudinal seismic bracing of the pipe in these instances.
6. There may be situations where the Construction Manager wants to control where certain anchors are located, the level of forces that can be transmitted to structures, the direction that expansion growth is allowed, or requires use of particular piping elements. In such cases these elements will be specified on the drawings and incorporated into the Design Professional's design. Mandatory anchorage locations identified on the drawings and maximum limitations, if any, for structure loads from the anchor will be as indicated on the drawings, identifying location and the maximum force that can be imposed on the structure. Where structural load would be exceeded, provide piping flexibility or expansion joints to reduce the maximum loading imposed on the structure.
7. For general understanding of intent and bidding purposes, general support locations, arrangements, types and means of attachment may be shown on the drawings. Some of the elements may be specifically designed and detailed. If a particular type of support, anchor, seismic restraint or expansion element is detailed on the drawings, then incorporate those elements into the Contractor's design. Include all elements of the piping system in Piping submittals by the Contractor, including those portions directed by the Construction Manager and complete piping runs.
8. Calculate the structural reaction loads for all fixed supports and indicate the calculated reaction loads on the submitted layout drawings. Notify the Construction Manager if any elements specified on the Drawings are incompatible with the overall piping system and its function.
9. Include consideration of and provisions for:
    a. Support and restrain pipe independent of support or restraint provided by equipment or without equipment supported loads exceeding equipment manufacturer's nozzle loading recommendations. Obtain maximum nozzle loads from the equipment manufacturer.
    b. Routing of pipe to provide access aisles free of obstruction and worker hazards. Unless otherwise specified or approved by the Construction Manager, the minimum clear space between equipment is 36 inches horizontally. Minimum vertical clearance is 7 ft above the floor or local grade at pedestrian access aisles and egress paths. Minimum clearance for equipment access aisles in galleries, tunnels and utilidors is 10 ft by 10 ft.
    c. Electrical bonding for all gas, fuel, and pneumatic conveyance systems.
    d. Dielectric separation, as specified.
10. Include all elements of piping systems required for fabrication and construction in the piping layout submittals. Depict couplings, support, restraint, anchorage, expansion control measures and other elements of the piping system.
11. Depict fitting angles and vertical and horizontal pipe locations, as determined by the Contractor, on piping layout drawings.
12. Do not interfere with maintenance functions and access around equipment, including monorails and hoists.

PART 2 PRODUCTS

2.01 PIPE MATERIALS - GENERAL

A. All pipe materials to be new, free from defects and conforming to the requirements and standards identified in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) and related sections.

B. New and existing piping is designated by process service rather than pipe material. Existing pipe material types may not be the same as material types specified for new piping. Investigate connections to existing piping and provide suitable connections, including electrical isolation, as necessary.

C. Fittings and Coupling Compatibility: To assure uniformity and compatibility of piping components, furnish fittings and couplings for grooved-end or shouldered-end piping systems from the same manufacturer.

D. Buried Piping: Size temporary and/or permanent thrust restraints. Design restraint systems to allow complete piping system disassembly without destruction of any portion of the piping system.

2.02 MATERIAL FOR PIPING SUPPORT, SEISMIC RESTRAINTS AND PIPE ANCHORS

A. This paragraph specifies materials for pipe supports specified in Section 40 05 07, seismic restraints specified in Section 40 05 07.13, pipe anchors, certain expansion control elements specified in Section 40 05 07.16, and all associated appurtenances. Section 01 61 45 defines environmental exposures by physical location. Pipe Support, Seismic Bracing, and Pipe Anchor materials are specified based on the environmental exposure specified in Section 01 61 45. Provide Pipe Support, Seismic Bracing and Pipe Anchor components fabricated from materials as specified in the following table:

Environmental Exposure or Pipe Material	Materials [1]	Nuts, bolts, washers, and fasteners
Outdoor	Steel, hot dip galvanized after fabrication	Type 304/316 stainless steel
Indoor, Dry	Steel, hot dip galvanized after fabrication	Steel, Zinc plated or hot-dip galvanized after fabrication
Indoor, Wet	Type 316 stainless steel or FRP	Type 316 stainless steel
Chemical Corrosive	Fiberglass (FRP)	Type 316 stainless steel
Head Space	Type 316 stainless steel or FRP	Type 316 stainless steel
Submerged	Type 316 stainless steel or FRP	Type 316 stainless steel
Undefined	Type 316 stainless steel or FRP	Type 316 stainless steel
Stainless steel piping	Same type of stainless steel as the pipe or FRP	(per area as defined in this table)

Notes:

1. *Where materials as designated in drawing details or indicated in other specification sections, those requirements govern over the provisions of this table.*

2.03 PIPE AND VALVE COMPATIBILITY

A. Coordinate the selection of pipe materials, linings, and end connections so that valves operate properly over their entire range (e.g., sufficient disk clearance for butterfly valves). Support wafer style valves or spectacle flanges between flanges of equal inside diameter.

2.04 BONDING JUMPERS

A. Provide plated, flexible copper braid jumpers with unplated copper ferrules for attachment to pipe flanges, rated for a 100 amp minimum. Provide Burndy Electrical, Type B series, or Approved Equal, and sufficient conductive, anti-oxidant compound (Burndy Electrical Penetrox series or Approved Equal) to protect ferrules.

2.05 JOINTS – GENERAL

A. Provide joints for disassembly within 3.0 ft of any connection to equipment, on both sides of structural penetrations, and within 2.0 ft of all threaded end valves.

B. Unless otherwise specified on the drawings or in equipment specifications, adapt all equipment connections to a flanged connection compatible with the connected piping system.

C. Flexible Joints at Structural Joint Crossings: Provide a flexible joint (or joints) on all piping crossing structural joints.

2.06 FLANGES AND OTHER COUPLINGS

A. Pipe connections are specified in the Piping System Schedules in Sections 40 05 02.00 through 40 05 02.99

B. General requirements for flanges are as follows:
   1. Where raised-face and flat flanges are provided for connection, reface the raised-face flanges. Flange face to be flush with flat-faced companion flanges on flat-faced valve or equipment flanges.
   2. Provide flat-faced flanges on each side of butterfly valves.
   3. For steel piping, provide weld neck flanges on both sides of wafer or lug body valves.

C. Slip-on flanges that are attached to a pipe by means of set screws and gaskets (uni-flange, etc.) are not acceptable.

2.07 FITTINGS – GENERAL

A. Fittings are specified in the Piping System Schedules.

B. Provide eccentric reducers in horizontal lines with the flat side on top, unless specified otherwise on the drawings (e.g., flow meters in horizontal runs requiring submergence).

C. Provide concentric reducers in vertical lines, unless otherwise specified on the drawings.

D. Provide reducers upstream and downstream of flow measurement devices to adapt line size to the specified flow measurement device dimension. Coordinate with the specific instrument requirements.

E. Provide long radius (greater than or equal to 1.5 x nominal diameter) elbows unless otherwise specified on the drawings.

2.08 GASKET MATERIALS

A. For flat faced flanges, use full-face gaskets. For raised-face flanges, use ring type gaskets. Conform to ANSI B16.21.

B. Refer to the Piping System Schedule for the specified gasket material. Material designations used in the detailed pipe specification sheets are as follows:
   1. EPDM: ethylene-propylene-diene-terpolymer 70 durometer
   2. Neoprene: neoprene (black) 70 durometer
   3. Nitrile: nitrile (Buna N)
   4. SBR: Styrene-butadiene (red)
   5. Natural rubber: natural rubber
   6. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400), and neoprene binder: 1.7 MPa (ASTM F152), 0.2 mL/h Leakage Fuel A (ASTM F37)
   7. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400) and SBR binder: 1.7 MPa (ASTM F152), 0.1 mL/h Leakage Fuel A (ASTM F37)
   8. Gylon - Type 1: Garlock Style 3500: 1.35 MPa (ASTM F152), 0.22 mL/h Leakage Fuel A (ASTM F37)
   9. Gylon - Type 2: Garlock Style 3510: 1.35 MPa (ASTM F152), 0.04 mL/h Leakage Fuel A (ASTM F37)
   10. CPE - Chlorinated Polyethylene
   11. Spiral-wound: per ASME B16.20, rated to 1200 degree Fahrenheit Flexitallic SS316L or approved equal
   12. PTFE bonded EPDM, full-face gaskets
   13. Viton/FKM – Fluoroelastomer, 75 Durometer

2.09 DISSIMILAR METAL CONNECTIONS

A. Where dissimilar metals are to be connected, provide dielectric fittings and/or isolating flanges, including bolt sleeves and washers, according to Section 40 05 06.

2.10 CATHODIC PROTECTION

A. Provide cathodic protection of piping, pipe fittings, and appurtenances where specified on the drawings.

2.11 STRUCTURAL ELEMENT PENETRATIONS

A. Penetrations through structural elements are referenced to a custom detail or Standard Detail. Where a penetration detail is not specified, conform to the Standard Detail relevant to the type of structure, exposure, and type of pipe.

B. Provide pipe sleeves capable of supporting the loads applied during placement of concrete or during block work erection.

2.12 PIPE MARKERS, DETECABLE WARNING TAPE, AND TRACER WIRE

A. Pipe marker, detectable warning tape, and tracer wire materials per Section 40 05 45.

PART 3 EXECUTION

3.01 PREPARATION

A. Prior to installation, inspect, and field measure to ensure that previous work is not prejudicial to the proper installation of piping.

B. Pothole existing pipe at connections to new pipe to confirm material and joints prior to submittal of pipe layout drawings.

C. The Drawings are, in part, diagrammatic, make all minor modifications to suit installed equipment and structural element locations and elevations and coordinate with electrical construction.

D. Provide details of connections to new and existing equipment, piping, and structures in piping layout drawing submittals. Unless otherwise specified on Drawings, piping fitting angles and vertical and horizontal pipe locations shall be determined by Contractor.

E. Piping arrangements indicated on the drawings have been estimated from the approximate configuration of the type of equipment listed in the equipment specifications. If the equipment to be provided does not have the same configuration, modify the piping arrangement as necessary. Include any piping modifications in shop drawings submitted prior to fabrication or installation.

3.02 PIPE SUPPORT, ANCHORAGE, AND SEISMIC BRACING

A. Support piping with anchor brackets, guides, saddles, or hangers. Pipe movement due to thermal expansion and internal pressure and dynamic forces shall be accommodated by pipe springing, anchors, expansion joints, and guides selected for the specific purpose by the Design Professional retained under the provisions of this Section. Provide supports on each run at each change of direction.

B. Provide seismic bracing as required to resist seismic loads.

C. Do not use existing pipes and supports to support new piping. Existing tunnel pipe support racks can be used for new pipe if the Design Professional determines that the existing rack components are adequate to support the additional load.

D. Install expansion loops, anchors, expansion joints, and guides where specified on the drawings.

3.03 PIPING CONNECTIONS TO MACHINES

A. Align piping at machine connections in all planes to permit insertion of bolts at bolted connections or coupling screwed connections without using jacks, come-a-longs or other mechanical means to align field piping with the connections at the machines.

B. Do not force bolts into mating flange bolt holes. Align flange bolt holes to permit insertion of bolts by hand (without tools, hammering, or prying).

C. Use of 'dutchmen' mitered sections or similar specials to achieve the required alignment with machine connections are strictly prohibited.

D. Provide equipment connection fittings per Section 40 05 06 as specified on the drawings.

3.04 JOINT AND COUPLING OPTIONS

A. Provide pipe connection (joint and coupling) options as specified in the Piping System Schedule.

B. If a Piping System Schedule lists several connection options, then any of the listed options may be used for a particular pipe material, but the selected option shall be used consistently. For example, if flanged or grooved connections are specified and grooved are represented on the Drawings, then flanged may be installed in lieu of the grooved couplings specified on the drawings.

C. Connecting straight runs of pipe by welding is acceptable only where the individual Piping System Schedule allows welding as a connection option.

D. Where connections other than those indicated on the Piping System Schedule are specified on the Drawings, locate the connection specified on the drawing at the specific location indicated on the drawing.

E. Provide rigid, non-rotating connections at all valves and equipment.

3.05 SMALL BORE UTILITY PIPING

A. Field route small bore (generally less than 3-inch) diameter branch piping for utility services.

B. In general, small bore utility branch piping is not specified on the Drawings unless a specific pipe routing or configuration is to be provided or where necessary to show valves or instrumentation requiring electrical connections.

C. Distribution lines for small bore utility piping are specified on the Drawings along with service connection routes to locations that require utility service piping.

D. Install small bore utility piping that must be drained to provide freeze protection with a continuous slope down to the drain.

3.06 BONDING

A. Bonding jumpers shall be as specified in this Section.

B. Bonding shall be provided for all gas, fuel, and pneumatic conveyance systems to control static electricity. Provide bonding jumpers to the following piping systems: NG

C. Construct electrically continuous piping for the process services listed above and connect directly or indirectly to earth ground.

D. Provide bonding jumpers where sections of pipe are interrupted with non-conducting sections, fully lined valves that are not through-bolted or other interruption in continuity.

E. Remove any coatings, dirt, grease or other contaminants from flanges where jumpers are to be installed. Apply sufficient conductive, anti-oxidant compound to protect the entire ferrule from galvanic action and hydrogen sulfide attack.

3.07 SEWER AND DRAIN PIPING

A. Run horizontal drainage piping as straight as practicable and at uniform pitch.

B. Install pipe 3-inch or less in diameter with slope of not less than two percent, unless otherwise specified on the Drawings.

C. Install pipe larger than 3-inch diameter with slope of not less than one percent, unless otherwise specified on the Drawings or required by the Plumbing Code.

3.08 SLEEVES

A. Unless otherwise noted in the specified pipe penetration details or otherwise approved by the Construction Manager, provide sleeves where piping passes through a wall, floor, or ceiling.

B. Locate and place sleeves prior to construction of cast-in-place elements and prior to the construction of concrete and masonry building elements.

3.09 PIPE JOINTS AND CONNECTIONS

A. Field cuts for glass-lined pipe are not permitted.

B. Cut pipe with appropriate tool and deburr.

C. Make joints tight. Test and remake leaking joints with new materials. Do not use thread cement or caulking to remake joints.

D. Do not use sharp toothed wrench in making up brass pipe, or chrome plated items.

E. Provide thread forms and length in accordance with ASME standards. Use lubricant or sealant on male threads suitable for proposed pipe service.

F. Clean joints before soldering. Use flux and alloy appropriate for specified operating temperature and pressure.

G. Welding procedures, welder certification/qualification, and weld testing per ASME Section IX, Boiler and Pressure Vessel Code. Make welds per the specified standard when ASME B31.1 or ASME B31.3 are specified for a Piping System in the Piping System Schedules (Sections 40 05 02.00 through 40 05 02.99).

H. Coat gasket with gasket manufacturer's recommended lubricant between flange faces.

3.10 TAKEDOWN COUPLINGS

A. Takedown Couplings: Provide takedown couplings at the locations specified on the Drawings in accordance with this Section.

B. Provide takedown couplings at changes in piping direction and where specified in the Drawings on straight runs of pipe.

C. Provide screw unions, flanged or grooved end coupling type joints as takedown couplings.

D. Use flanged or grooved end joints on pipelines 1.5-inch diameter and larger.

E. Where piping passes through walls provide takedown couplings within 40 inches of the wall.

F. Provide a union or flanged connection within 24 inches of each threaded end valve.

3.11 INSTALLATION OF BURIED PIPE AND PIPE BELOW STRUCTURES

A. Trenching and backfill for buried pipe: conform to Section 31 23 00.

B. Pipe laying and bedding: conform to Section 31 23 00.

C. Restrain all plugs, caps, tees and bends in buried pressure piping systems by means of restrained joints as specified in the respective Piping System Schedule.

D. In accordance with Section 40 05 06, and where specified on the Drawings, provide flexibility per specified details where buried pipe passes under, through, or is connected to structures. Provide restrained joint connections or provide restraints across each un-restrained joints.

E. Install pipe in straight alignment. Do not exceed 3/8-inch variance over 30 ft from the true alignment in any direction.

F. Slope gravity lines uniformly from point of origin to discharge.

G. Ensure the pipe alignment stays true during and after placement of concrete encasement.

H. Ensure that the method used to prevent pipe uplift during placement of concrete encasement results in an invert and crown true to intended grade.

I. Maintain circular cross section of pipe.

J. Provide lean concrete below the underside of the slab or footing for backfill over pipe laid below structures when pipe is less than 6 inches below the underside of the slab or footing, unless specified otherwise. Place concrete in accordance with Section 03 30 00.

K. Provide Heat-Shrinkable Cross-Linked Polyolefin Coating or Tape Wrap coating on all flanged, grooved, and welded joints that are buried or below structures.

L. Provide Petrolatum Tape wrap on all valves and mechanical pipe couplings that are buried or below structures. Install per manufacturer's recommendations. Candidate Manufacturers:
   1. Denso Densyl Tape
   2. #1 Wax Tape
   3. Approved Equal

M. Use anti-seize compound with all stainless steel nuts and bolts.

N. Provide detectable warning tape for all buried pipe. Provide tracer (locate) wire as specified in Section 40 05 45.

3.12 EXPOSED INSTALLATION

A. Fabricate and install domestic hot and cold water piping, sanitary piping and storm drainage piping in accordance with the Plumbing Code.

B. Provide pipe system layout in accordance with the following criteria:
   1. Drawings show general layout of piping. Exact dimensions determined by Contractor.
   2. Maintain minimum clear areas through tunnels and principal access aisles as specified in this Section.
   3. Expanding or swaging of tubing to fit IPS (Iron Pipe Size) fitting sockets is not permitted.
   4. Use reducing fittings where change in pipe size occurs.
   5. Use couplings only where pipe runs are longer than standard supplied pipe lengths.
   6. Make exposed polished or enameled connections to fixtures or equipment with special care to avoid damage to finished surfaces.
   7. Make changes in direction only with fittings.
   8. Install piping with not less than minimum slope to ensure adequate drainage and venting.
   9. Maintain clear areas around equipment to allow adequate access for maintenance as specified in this Section.
   10. Ensure valve operators are accessible from floor level. Provide chain wheel operators for valves with centerline elevations of 7 feet or above.
   11. Ensure piping ancillaries and in-pipe instrumentation is installed in accessible locations which do not create problems for traffic in the clear areas.

C. Make adequate provision in piping and pipe support systems for expansion, contraction, slope, and anchorage.

D. Install pipe support system to adequately secure the pipe and to prevent undue vibration, sag or stress.

E. Install expansion joints where specified on the Drawings or where required by the Design Professional, to allow for piping expansion and contraction.

F. Install expansion loops or bends where specified, or required by the Design Professional, to allow for proper pipe expansion. Construct expansion loops with long radius welded bends.

G. Provide temporary supports as necessary during construction to prevent overstressing of equipment, valves or pipe.

H. Accurately cut all piping for fabrication to field measurements.

I. Install pipes in straight alignment and parallel to wall. Do not exceed 3/8-in variance over 30 ft from the true alignment, in any direction.

J. Fabricate and assemble pipe runs so that the pipework is not stressed to achieve the desired alignment and that no stresses are transferred to equipment or equipment flanges. Unless stipulated by the Design Professional to address significant thermal strain, and accepted by the Construction Manager, the "springing" of pipe and fittings to ensure alignment is not permitted. Undo and subsequently remake all pipework connections where so instructed by the Construction Manager to ensure that unintended springing does not occur. Take care not to damage equipment, valves, or flanges.

K. Slope instrument air piping to condensate traps.

L. Do not cut or weaken the building structure to facilitate installation of piping.

M. In parallel pipe runs, offset flanges and/or grooved joint fittings by a minimum of 8 inches longitudinally to allow for proper access.

N. In vertical pipe runs of pipe diameter greater than 10 inches, provide 8-inch long spool piece on lower side of each valve.

O. Do not install water piping over electric switchboards, transformers, cable tray or electric motor starters.

P. Provide pipe markers for all exposed pipe.

3.13 THREADED JOINTS

A. Conform to the requirement of ANSI B31.1.

B. Ream the end of all pipes to remove all burrs and cuttings when fabricating threaded joints.

C. Clean out pipe and repair linings and coatings prior to joining.

D. Apply Teflon tape to male threads and join pipe. Use both Teflon tape and Teflon sealing compound on stainless steel pipe threads. Do not apply extra tape to make up for slack in the joint.

3.14 FLANGED JOINTS

A. Maintain consistent flange bolt hole positions along the entire length or run of the pipe.

B. For pipe installed with a horizontal axis, position flange bolt holes so that the vertical centerline of the flange face bisects the arc between flange bolt holes (“Two-Holed”).

C. For pipe installed with a vertical axis, position flange bolt holes so that the horizontal centerline of the flange face bisects the arc between flange bolt holes and is perpendicular to the closest structural wall (“Two-Holed”).

D. Clean flanges and gaskets prior to connection.

E. Lubricate gaskets with gasket manufacturer’s recommended lubricant and apply anti-seize compound to all bolts.

F. Bring flanges into close parallel and lateral alignment.

G. Tighten bolts progressively. Proceed from side to side of the flange.

H. Use proper length bolts for each size flange on flanged connections. Washers may not be used to take up excess bolt length. Provide approximately two full threads bolt projection beyond nuts. Bolts with excessive length of exposed threads will not be permitted. All-thread rod is not acceptable for bolting flanges.

I. When joining steel to cast iron flanges, take care to avoid damage to the cast iron flange. Ensure both flanges are flat-faced and use full face gaskets.

J. Align flanges which connect piping to mechanical equipment to close parallel and lateral alignment prior to tightening bolts. Do not place strain on the equipment.

K. Allow a minimum of 6 inches’ clearance to face or 8 inches to edge of flange to wall, floor, or ceiling unless otherwise specified.

3.15 INSULATION

A. Insulate piping systems in accordance with the Piping System Schedules (Sections 40 05 02.00 through 40 05 02.99) and Section 40 42 00.

3.16 FLEXIBLE HOSE CONNECTORS

A. Accurately align pipelines to receive flexible connectors before installing the connectors. Do not stretch, compress, misalign or offset the connectors.

B. Align and install each flexible connector in accordance with the manufacturer's instructions.

C. Support, anchor and guide the piping so that the flexible hose connectors are not required to absorb any axial compression or elongation.

D. Do not torque or twist the flexible connectors.

E. Check bolt tightness and tighten where necessary, a maximum of one week after commissioning and periodically thereafter.

3.17 EXPANSION JOINTS

A. Accurately align pipelines to receive expansion joints before installing the joint. Do not stretch, compress or offset the joint to fit the piping. Install expansion joints in accordance with manufacturer's instructions prior to releasing preload.

B. Align and install each expansion joint in accordance with EJMA standards and with the manufacturer's written instruction; properly guide and anchor all expansion joints. No lateral movement is permitted on compensator type expansion joints.

C. On rubber expansion joints, check bolt tightness, and tighten where necessary one week after Commissioning is completed.

3.18 REPAIR/RESTORATION

A. Repair pipe with damaged shop-applied protective linings in accordance in accordance with specified standard (e.g. AWWA C210) or accordance with the lining manufacturer's directions, if no standard is cited.

B. Damaged glass lining cannot be repaired. Replace piping with damaged glass lining.

C. Patching inserts, overlays, or pounding out of dents is not be permitted.

D. Repair pipe with damaged protective coatings and holdback areas for welding and other field fabrication, as follows:
   1. For shop-applied coatings, not subject to Section 09 90 00 requirements, in accordance with specified standard (e.g. AWWA C210) or in accordance with the coating manufacturer's directions, if no standard is cited.
   2. For coatings applied pursuant to Section 09 90 00 requirements, apply repair coatings in conformance with the applicable Section 09 90 00 coating system, including thickness and stipulated preparation of the lowest full thickness coating layer (i.e. exposed metal would require full profile preparation and specified multi-layer coating restoration).
   3. Prepare areas to be repaired not less than 2-inches beyond damaged areas and feather repair coating into adjacent areas.
   4. Repair to provide equivalent protection to undamaged coatings and a uniform appearance when judged from 4 feet away.

E. Other requirements may be stipulated in related piping sections.

3.19 FIELD QUALITY CONTROL

A. Inspections:
   1. Inspect and provide reports as specified in Section 40 05 07, Section 40 05 07.13, and Section 40 05 07.16.
   2. Submit the Design Professional's final report before beneficial occupancy by the Owner.

3.20 TESTING

A. Provide 24 hours notice prior to testing.

B. Do not insulate or conceal work until piping systems are tested and have met all required criteria.

C. Complete any required weld tests.

D. Supply all water, air, and inert gases required for pressure testing.

E. Supply all pumps, compressors, gauges, etc. required for testing.

F. Install air threadolets, air relief valves, and line fitting valves as necessary to complete testing. Remove after testing and plug threadolets.

G. Cap or plug all lines which are normally open ended. Remove on completion of testing.

H. Provide all temporary thrust restraints necessary for testing. Remove upon completion of testing.

I. Test all underground lines prior to backfilling. Do not place concrete encasement until lines are tested and have met all required criteria.

J. Test all existing piping where it connects to new piping to the first valve in the existing piping. Repair any failures in existing piping which occur as a result of the test after informing the Construction Manager of such failure.

K. Isolate all pumps and low pressure equipment and appurtenances during testing so as not to place any excess pressure or thrust forces on the equipment.

L. Where defective material or equipment is identified, repair or replace using new material.

M. Flush and drain liquid pipes after pressure tests. Purge all gas pipes after pressure tests using inert gas.

N. Dispose of flushing water in manner approved by the Construction Manager, which causes no damage to buildings or siteworks.

3.21 HYDROSTATIC PRESSURE TESTING OF LIQUID LINES

A. Hydrostatically test all lines normally used for the conveyance of liquids using water as the test medium, unless otherwise specified in this Section.

B. Test pressures and durations as specified in the Piping System Schedules.

C. Ensure all lines are filled with water. Bleed air from all high spots using the taps provided specifically for that purpose.

D. Lined pipelines: Allow filled pipeline or section thereof to stand under a slight pressure for at least 8 hours (24 hours for cement mortar lining) to allow the lining to absorb water and to allow the escape of air from air pockets.

E. Zero leakage is permitted throughout the specified test period for all exposed piping, buried insulated piping, and any liquid chemical lines.

F. Show evidence of leakage rates below 0.02 gal per hour per inch pipe diameter per 100 ft of pipe length for buried piping, unless otherwise specified.

G. Test drains in accordance with the Plumbing Code.

H. For hydraulic and lube oil systems, test using the medium of service. Provide zero loss of pressure throughout the specified test period.

3.22 PNEUMATIC PRESSURE TESTING

A. Use nitrogen gas or oil free dry air to test piping systems where nitrogen or air is the specified testing medium in the Piping System Schedule.

B. Submit a testing plan and a safety plan for each piping system that will be pressure tested with nitrogen gas or oil free dry air. Do not perform pressure testing with air or nitrogen until a favorable review of the safety plan and testing plan for the piping system has been returned from the Construction Manager. Comply with all workplace safety and pressure vessel safety codes and guidelines.

C. Provide a separate pressure relief valve for pneumatic pressure testing.

D. Locate pressure relief valve within visual range of the test gauge and with exhaust to a safe location.

E. Set relief valve at not more than full test pressure plus 10 percent.

F. Continuously monitor and control testing to assure personnel safety and piping integrity.

G. Remove all personnel from areas where piping will be subjected to pressure tests and prevent entry into testing areas until test pressure has been relieved.

H. Protect installed work from potential damage from pressure testing failures. The Contractor is responsible for any damage or injury resulting from failed pressure testing with air or nitrogen.

I. When using nitrogen or air to test steel or stainless steel pipelines, gradually introduce the test gas up to a pressure of 45 psig or 1/3 of specified test pressure, whichever is less.

J. While maintaining this pressure, test lines for leaks using soapy water.

K. When the line is free from leaks at this pressure, increase by increments of 50 psig or 1/3 of specified test pressure (whichever is less) to the specified test pressure.

L. After each increment, retest using soapy water; take corrective action as necessary.

M. When the system is free from leaks at the test pressure, depressurize the system slowly.

N. To prevent the entrance of water or moisture into the medium source, disconnect the test source from the system and cap.

O. Where specified, maintain nitrogen pad after testing until the line is put into service. Label any piping for which a pad is provided and maintained.

P. Provide high purity nitrogen gas used for testing, in cylinders fitted with pressure regulators for 0 to 300 psig and all necessary fittings and adaptors necessary to complete the connection between the source and the system header. Provide self-relieving type pressure regulator that vents to the atmosphere and include a throttling valve.

Q. Provide oil free air with a relative humidity of zero for testing. Provide all fittings, adaptors, accessories, and the pressure regulator and throttling valve that are suitable for pressure testing with air and rated for 300 psig service.

3.23 PRESSURE TESTING OF GAS, AIR, AND VAPOR LINES

A. Hydrostatically or pneumatically pressure test, as specified in the Piping System Schedules, all lines normally used for the conveyance of gas, air, and/or vapor in accordance with ASME procedures for testing pressure piping and CAN/CGA B149.6 for buried digester gas piping. Pneumatically test all instrument air lines in accordance with ISA-S7.0.01 and digester gas piping in accordance with CAN/CGA B149.6.

B. For gas and air lines to be hydrostatically tested, check support system to ensure it is capable of withstanding loads imparted by test method. Provide any additional supports necessary in a manner acceptable to the Construction Manager. At the Construction Manager's request, provide calculations indicating design of temporary support system.

C. Test pressures are identified in the Piping System Schedule.

D. Zero leakage rate is required at the specified test pressure through the test period. Prior to commencing test using air, ensure air will be at ambient temperature and specified test pressure.

E. Do not exceed the maximum specified leakage rate during the test period for all other systems tested with air.

F. Remake all joints which display leakage and retest.

3.24 TESTING OF HAZARDOUS GAS AND LIQUID LINES

A. The following process pipes shall be tested as Hazardous Gas or Liquid lines: NG.

B. Remove components which may be damaged by test pressures and plug openings. Provide tee in any existing lines to be tested adjacent to the terminal valve.

C. Pressure test after cleaning.

D. Zero leakage at specified test conditions is required. Repair and retest lines until successful test is achieved. Test all digester gas lines in accordance with CAN/CGA B149.6.

E. Plug and/or disconnect all vents to the atmosphere, close all valves to the atmosphere, and open all in-line valves. Return the system to its appropriate operating condition after testing, including resetting of vents and valves.

F. Hydrostatically test PVC and CPVC pipelines using water as the test medium, as specified in the Piping System Schedules. Where support systems are not designed for hydrostatic testing or drying of steel pipelines is impractical, with the Construction Manager's approval, the Contractor may use nitrogen gas or dry air as the test medium, providing the specified safety plan is submitted and necessary safety precautions are implemented to minimize the risk incurred when performing such a test.

G. Replace all moisture absorbing gaskets and valve packing after hydrostatic testing.

H. After testing, dry all lines.
   1. Steel or stainless steel Lines: Pass steam through the lines from the high end until all lines are thoroughly heated. Allow condensate and foreign material to drain during steaming. Disconnect and drain lines from all low points. While lines are warm, blow dry, oil-free air with a dew point below -40 degrees F through the system until the existing dew point is the same as the supply air. Fix valves in the half open position during drying. Ensure that valves temporarily removed from the system during drying operations are completely free of moisture prior to reinstallation.
   2. PVC Lines: Drying applies solely to vacuum lines. Drain and remove all free water and moisture from the system. Swab the pipe to remove any excess water. Air dry the pipe in the same manner as steel lines, additionally ensuring that the entering air temperature is not greater than 120 degrees F.

I. Fill the line with inert gas if service gas is reactive with air.

J. Introduce service gas immediately after testing and drying and inert gas filling. Test the system for leaks. Allow time for the complete replacement of air or inert gas from the piping with the service gas.

K. Use an appropriate sensing device when testing for leaks.

L. If leaks are detected when the system is tested with service gas, do not implement repairs until all gas has been purged from the system. Repeat the hydrostatic testing and drying sequence prior to retesting the line with service gas.

3.25 CLEANING AND FLUSHING

A. After installation and prior to testing, perform initial cleaning of process and utility lines. Clean piping greater than 6 inches and less than 24 inches by passing a tightly fitting cleaning ball or swab through the pipeline, unless specified otherwise. Lines greater than 24 inches may be cleaned manually or with a cleaning ball or swab. Give lines smaller or equal to 6 inches an initial flush or purge.

B. After initial cleaning, connect the piping systems to related process and mechanical equipment. Insert temporary screens, provided with visible locator tabs, in the suction of pumps and compressors in accordance with the following table:

Suction size, in.	Maximum screen opening, in.
0 – 1	1/16
1-1/4 – 3	1/4
3-1/2 – 6	1/2
Over 6	1

C. Maintain the screens during testing, flushing/purging, initial startup, and the initial operating phases of the commissioning process. In special cases and with the Construction Manager's acceptance, screens may be removed for performance tests. Install screens for clear water testing and initial operation on liquid systems handling solids. Initial operation on solids systems following clear water testing may be without screens.

D. Unless specified otherwise, flush liquid systems after testing, with clean water and screens in place. Maintain flushing for a minimum period of 15 minutes and until no debris is collected in the screens.

E. Remove the screens and make the final connections after the screens have remained clean for a minimum of 24 consecutive hours of operation. Keep screens in place for 24 hours of clean water operation on solids handling systems; remove prior to placing the system into solids handling service.

F. In air or gas systems with pipe sizes less than or equal to 6 inches, purge with air and/or inert gases before testing. Upon completion of testing and cleaning, drain and dry the piping with a dry air stream. Satisfy ANSI/ISA-S7.0.01 standards for instrument air systems.

G. Purge digester gas, natural gas, and propane systems with nitrogen gas and provide a nitrogen pad maintained at 10 psig until put in service. Purge and dry digester gas systems in accordance with CGA B149.6.

H. For hazardous gas and liquid systems, clean interior of the pipelines by drawing a cloth or swab impregnated with an appropriate solvent (carbon tetrachloride or trichloroethylene) through the pipe. Do not clean interior of refrigerant lines. Dismantle valves and hand clean. Plug lines at the end of each day. Properly dispose of all waste solvents.

I. Clean and flush piping connecting to HVAC equipment in accordance with Division 23.

3.26 DISINFECTION

A. Flush and disinfect lines intended for potable water service after testing in accordance with AWWA C651.

END OF SECTION

SECTION 40 05 02

PIPING SYSTEM SCHEDULES

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies a Piping System Schedule for each Process Service. Each Piping System Schedule specifies piping system materials for groups of similar process piping services.

B. The table in paragraph 1.01C lists process services and the corresponding Piping System Schedule that specifies piping system material requirements for the associated process piping service. See Part 4 for Piping System Schedules that define materials for piping services.

1. All Civil Yard Piping buried and 5 ft outside facilities see Civil drawings yard piping plans and profiles. Piping specification and materials are listed on plans and profiles.

C. Piping System Schedule assignments are listed in the following table:

Process Service	Process Service	Piping System Schedule	Test Pressure	Fluid Category	Pipe Marker Background Color
AW	AIRWASH	40 05 02.01	Air	Compressed Air	Blue
BW	BACKWASH	40 05 02.AA	High Head	Water	Green
CAR*	CARRIER PIPE	40.05.31.19	High Head	Solution	Gray/Orange
CAW	CHANNEL AGITATION AIR	40 05 02.01	Air	Compressed Air	Blue
CD	CHEMICAL DRAIN	40 05 02.BB	Gravity	Solution	Green
DR	DRAIN	40 05 02.89	Gravity	Wastewater	Green
DW	DECANT WATER	40 05 02.43	Gravity	Water	Blue
FEC*	FERRIC CHLORIDE	40 05 02.65	High Head	Toxic/Corrosive	Orange
FI	FILTER INFLUENT	40 05 02.23	Gravity	Water	Blue
FLR*	FLUORIDE	40 05 02.65	High Head	Solution	Gray
FMX	FLASH MIX	40 05 02.66	High Head	Solution	Gray
FTW	FILTER TO WASTE	40 05 02.AA	Gravity	Water	Green
FW	FILTERED WATER	40 05 02.23	Gravity	Water	Blue
HWR	HOT WATER RETURN	40 05 02.25	Test/Balance	Solution	Gray
HWS	HOT WATER SUPPLY	40 05 02.25	Test/Balance	Solution	Gray
NG	NATURAL GAS	40 05 02.17	Air	Flammable	Yellow
OF	OVERFLOW	40 05 02.AA	Gravity	Water	Green
PD	PROCESS DRAIN	40 05 02.AA	Gravity	Water	Green
PEA	ANIONIC POLYMER	40 05 02.63	High Head	Solution	Gray

Process Service	Process Service	Piping System Schedule	Test Pressure	Fluid Category	Pipe Marker Background Color
PEC	CATIONIC POLYMER	40 05 02.63	High Head	Solution	Gray
PEN	NONIONIC POLYMER	40 05 02.63	High Head	Solution	Gray
PW	POTABLE WATER	40 05 02.23	High Head	Water	Blue
RCW	RECYCLE WATER	40 05 02.23	High Head	Water	Blue
RDL	ROOF DRAIN LEADER	40 05 02.89	Gravity	Stormwater	Green
RW	RAW WATER	40 05 02.23	High Head	Water	Blue
SC*	SPARE CHEMICAL	40 05 02.63	High Head	Solution	Gray
SD	STORM DRAIN	40 05 02.CC	Gravity	Stormwater	Green
SH*	SODIUM HYPOCHLORITE	40 05 02.65	High Head	Toxic/Corrosive	Orange
SL	SOLIDS	40 05 02.53	High Head	Sludge	Green
SMP	SAMPLE	40 05 02.66	High Head	Water	Blue
SPD	SUMP PUMP DISCHARGE	40 05 02.AA	High Head	Water	Green
SS	SANITARY SEWER	40 05 02.89	Gravity	Wastewater	Green
SU	STRUCTURE UNDERDRAIN	40 05 02.CC	Gravity	Stormwater	Green
SUC	UNDERDRAIN COLLECTOR	40 05 02.CC	Gravity	Stormwater	Green
SW	SETTLED WATER	40 05 02.23	Gravity	Water	Blue
TWP	TEPID WATER	40 05 02.23	High Head	Water	Blue
UW1	UTILITY WATER	40 05 02.27	High Head	Water	Green
UW2	UTILITY WATER	40 05 02.27	High Head	Water	Green
VT	VENT	40 05 02.89	Gravity	Wastewater	Green
WBW	WASTE BACKWASH	40 05 02.AA	Gravity	Water	Green

* Extents of double containment pipe systems for chemical services are indicated on the drawings – double contained pipe shall be per Specification 40.05.31.19.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ASME B1.20.1	Pipe Threads, General Purpose
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250
ASME B16.3	Malleable Iron Threaded Fittings Class 150 and 300

Reference	Title
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Steel Butt Welding Fittings
ASME B16.11	Forged Steel Fittings, Socket Welding and Threaded
ASME B16.12	Cast Iron Threaded Drainage Fittings
ASME B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME B31.9	Building Services Piping
ASME B32	Solder Metal
ASME B36.10	Welded and Seamless Wrought Steel Pipe
ASME B36.19	Stainless Steel Pipe
ASME B1.1	Unified Inch Screw Threads
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM A47	Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106	Seamless Carbon Steel Pipe for High Temperature Service
ASTM A126	Grey-Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A135	Electric-Resistance-Welded Steel Pipe
ASTM A139	Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and Over)
ASTM A167	Stainless Steel and Heat-Resisting Chromium-Nickel Steel Plate
ASTM A181/181M	Forgings, Carbon Steel, for General Purpose Piping
ASTM A182/182M	Forged or Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/193M	Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service High Pressure Service and Other Special Purpose Applications
ASTM A194/194M	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service or High Temperature Service, or Both
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A240	Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A307	Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
ASTM A312/312M	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A320/320M	Alloy Steel Bolting Materials for Low-Temperature Service
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A409/A409M	Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

Reference	Title
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A536	Ductile Iron Castings
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A774/A774M	As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
ASTM A778	Welded, Unannealed Austenitic Stainless Steel Tubular Products
ASTM A1011/A1011M	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
ASTM B75	Seamless Copper Tube
ASTM B88	Seamless Copper Water Tube
ASTM B584	Copper Alloy Sand Castings for General Applications
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C361	Reinforced Concrete Low-Head Pressure Pipe
ASTM C443	Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	Circular Precast Reinforced Concrete Manhole Sections
ASTM D638	Test Method for Tensile Properties of Plastics
ASTM D792	Test Method for Specific Gravity and Density of Plastics by Displacement
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2513	Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2996	Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D3034	Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals
ASTM D3261	Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Fittings
ASTM D3350	Polyethylene Plastics Pipe and Fittings Materials
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM D4174	Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
ASTM D4894	Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
ASTM D4895	Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F894	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
AWWA C104	Cement–Mortar Lining for Ductile-Iron Pipe and Fittings

Reference	Title
AWWA C105	Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C110	Ductile-Iron and Grey-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron and Grey-Iron Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Grey-Iron Pipe with Threaded Flanges
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water and Other Liquids
AWWA C153	Ductile-Iron Compact Fittings
AWWA C200	Steel Water Pipe, 6 Inches and Larger
AWWA C203	Coal Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches through 144 Inches
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services - Sizes 4 Inch Through 144 Inch
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
AWWA C301	Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
AWWA C303	Reinforced Concrete Pressure Pipe - Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C600	Installation of Ductile-Iron Water Mains and their Appurtenances
AWWA C606	Grooved and Shouldered Joints
AWWA C651	Disinfecting Water Mains
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water
AWWA M11	Steel Pipe - A Guide for Design and Installation
CISPI 301	Specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings
EJMA STDS	Standards of Expansion Joint Manufacturers' Association, Edition No. 6
FSA	Fluid Sealing Association Technical Handbook, Rubber Expansion Joint Division
FEDSPEC, L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
MIL-H-13528B	Hydrochloric Acid, Inhibited, Rust Removing
MIL-S-8660C	Silicone Compound
MIL-STD-810C	Environmental Test Methods
MSS SP-25	Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-43	Wrought Stainless Steel Butt Welding Fittings
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends

Reference	Title
MSS SP-114	Corrosion Resistant Pipe Fittings Threaded and Socket Welding Class 150 and 1000
NSF/ANSI 61:	Drinking Water System Components – Health Effects
SSPC	Society for Protective Coatings
SAE J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems
	Insert applicable plumbing code (International, Uniform, California, etc.)
	_____Plumbing Code

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

B. Pipe Connections and Joints:
1. BABS – Bell and Ball Spigot
2. BAS – Bell and Spigot
3. BFW – Butt Fusion Weld
4. BSS – Bolted Split Sleeve Coupling
5. BW – Butt Weld
6. BSW – Butt-Strap Weld
7. CGRV – Cut (or Cast) Grooved End Coupling
8. CPLG – Coupling
9. CPO – Compression Type Push-On
10. CPRSN – Compression
11. DLW – Double Lap Weld (Bell and Spigot)
12. EFSW - Electro-Fusion Socket Weld
13. FLG – Flanged
14. FLRD – Flared
15. FP – Full Penetration
16. FSW – Fusion Socket Weld
17. HAS – Hub and Spigot, Compression (Cast Iron Soil Pipe)
18. HBLS - Shielded Hubless (Cast Iron Soil Pipe)
19. HGRV – HDPE Groove Coupling
20. HLF CPLG – Half Coupling
21. HPEG – HDPE Plain End with Gripping Teeth
22. HXGT - HDPE by Grooved End Transition
23. LR ELL – Long Radius Elbow
24. MJ – Mechanical Joint
25. PGRV - Proprietary Groove Coupling
26. PO – Push-on
27. RBAS – Restrained (Lap Welded) Bell and Spigot with O-ring rubber gasket
28. RGRV – Rolled Grooved End Coupling
29. RJC – Ring Joint Coupling
30. RMJ – Restrained Mechanical Joint

31. RPO – Restrained Push-On joint
32. SLV – Solvent Weld
33. SLDR – Solder or Brazing
34. SLW – Single Lap Weld (Bell and Spigot)
35. SR ELL – Short Radius Elbow
36. SW – Socket Weld
37. THD – Threaded
38. UN – Union

C. Flanges:
   1. FF – Full Face
   2. LF – Loose Flange
   3. LJ – Lap Joint
   4. LWN – Long Weld Neck
   5. RF – Raised Face
   6. SO – Slip-On
   7. THD – Threaded
   8. WN – Weld Neck

D. Materials:
   1. DI – Ductile Iron
   2. RCP – Reinforced Concrete Pipe
   3. RCP-LHP – Reinforced Concrete Low Head Pressure Pipe
   4. SS – Stainless Steel
   5. SV – Service (Cast Iron Soil Pipe available with SV rating or XH, extra heavy, rating)

E. Welding:
   1. FP – Full Penetration
   2. SML – Seamless
   3. WLD – Welded

F. Test Pressure:
   1. AM – Air Method
      a. Set nominal test to (110%* Pdesign) or (Pdesign + 50 psi), whichever is lower
   2. GR – Gravity Method
      a. 10 ft – coordinate with most-recent, local plumbing authority requirements.
   3. HH – High Head Method
      a. Set nominal test to (150%*Pdesign)
   4. TB – Test/Balance
      a. HVAC/Plumbing - See Divisions 22 and 23
   5. Pdesign
      a. Either the maximum utility pressure, or the pump or blower shutoff head, whichever is greater.

G. Other:
   1. CFT - Cured Film Thickness
   2. DFT – Dry Film Thickness
   3. Dim – Dimensions
   4. M or E Pipe – Matches or exceeds rating of connecting pipe
   5. Thk – Thickness
   6. Sch – Schedule
   7. Std – Standard
   8. STD – Standard Weight or Standard

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe size (nominal diameter) and the Process Service Identifier for the contents of the pipeline are specified in pipe line labels on the drawings.

B. Provide piping system materials and components per the Piping System Schedule assigned for the specified process service and pipe size.

C. The Rating column in the Piping System Schedule specifies the minimum acceptable pressure rating or wall thickness for the component of the piping system.

PART 3 NOT USED

PART 4 SCHEDULES

4.01 PIPESPEC SYSTEM SHEETS/DETAILED PIPING SPECIFICATION SHEETS.

A. Piping System Schedules follow this Section. Piping System Schedules are assigned a Section number in the range from 40 05 02.00 through 40 05 02.99.

END OF SECTION

Section 40 05 02. 01

Piping System Schedule, Process Air (Stainless Steel)

Process Service	Aeration Wash	Channel Agitation Wash						
Process Service Identifier	***AW***	***CAW***						

General Requirements

A. Testing Requirements: Pressure: 20 psig. Duration: 120 min. Medium: Air

B. Comply with the provisions of Section 40 05 01 in addition to the requirements specified herein. Refer to Section 40 05 02 for definitions of abbreviations and acronyms used in this schedule.

C. Full-Faced flanges mated with raised face flanges are not permitted.

D. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

E. Pipe threads per ASME B1.20.1.

F. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 304L to Type 304L pipe material.)

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
4. Provide long radius five cut mitered elbows for segmentally welded fittings.
5. Stainless steel stub end for use with Lap Joint flanges. Stub end dimensions and materials to match pipe. Fillet radius of stub ends compatible with inner corner radius of backing flange bore.
6. For Headspace, Process Corrosive, and Submerged area exposures, use stainless steel flanges with stainless steel bolts and nuts.
7. Factory coat carbon steel/ductile iron backing ring flanges with Liquid Epoxy per AWWA C210, 16 mils DFT, minimum.
8. Provide stainless steel flange bolts, nuts, and washers with stainless steel flanges.
9. Insulate for Energy Conservation in Indoor Dry and Indoor Wet area exposures. Insulate for Personnel Protection in other area exposures.
10. Provide weld neck flanges on both sides of wafer, lug body, and flanged valves ½ thru 24 inch. Provide Slip on flanges on both sides of wafer, lug body, and flanged valves 26 thru 72 inch.

Section 40 05 02. 01 — Piping System Schedule, Process Air (Stainless Steel)

Process Service	Aeration Wash	Channel Agitation Wash						
Process Service Identifier	***AW***	***CAW***						

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged – Exposed

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/8 thru 2-1/2	Stainless Steel: ASTM A312-TP304L, SML, Dim. Per ASME B36.19	Sch. 40S	BW, SW, THD, FLG	40 05 23	
	3 thru 8	Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	Sch. 5S	BW, FLG, BSS	40 05 23	
	10 thru 12	Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	Sch. 5S	BW, FLG, BSS	40 05 23	
		Fabricated Stainless Steel: ASTM A778-TP304L.	12-gage plate	BW, FLG, BSS		
	14 thru 18	Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	Sch. 5S	BW, FLG, BSS	40 05 23	
		Fabricated Stainless Steel: ASTM A778-TP304L	11-gage plate	BW, FLG. BSS		
	20	Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	Sch. 5S	BW, FLG, BSS	40 05 23	
		Fabricated Stainless Steel: ASTM A778-TP304L	10-gage plate	BW, FLG, BSS		
	22 thru 36	Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	Sch. 5S	BW, FLG, BSS	40 05 23	
		Fabricated Stainless Steel: ASTM A778-TP304L	3/16 in. Thk.	BW, FLG, BSS		
	38 thru 48	Fabricated Stainless Steel: ASTM A778-TP304L	1/4 in. Thk.	BW, FLG, BSS	40 05 23	
	50 thru 72	Fabricated Stainless Steel: AWWA C220-Type 304L	5/16 in. Thk.	BW, FLG, BSS	40 05 23	
Lining for Pipe & Fittings	All	None	—	—	—	
External Coating	Pipe and Fittings	None	—	—	—	7
	Valves	Manufacturer's Standard Primer or Primer and Finish Coating: Shop or Factory Applied	—	—	—	
Fittings	1/8 thru 2-1/2	Forged Stainless Steel: ASTM A182-F304L, Dim. per ASME B16.11	Class 3000	SW, THD	40 05 23	
		Wrought Stainless Steel: ASTM A403-WP304L, Dim. per ASME B16.9	Sch. 40S	BW, FLG		
		Cast Stainless Steel: ASTM A351-CF8M, Dim. per ASME B16.3	Class 150	THD		
	3 thru 24	Wrought Stainless Steel: ASTM A403-WP304L, Dim. per ASME B16.9	Sch. 5S	BW, FLG, BSS	40 05 23	3
	26 thru 48	Fabricated Stainless Steel: ASTM A774-TP304L, Dim. per AWWA C226	Match pipe Thk.	BW, FLG, BSS	40 05 23	4

Section 40 05 02. 01 — Piping System Schedule, Process Air (Stainless Steel)

Process Service	Aeration Wash	Channel Agitation Wash						
Process Service Identifier	***AW***	***CAW***						

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged – Exposed

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
	50 thru 72	Fabricated Stainless Steel: AWWA C220-Type 304L, Dim. per AWWA C226	Match pipe Thk.	BW, FLG, BSS	40 05 23	4
Taps	1/8 thru 2-1/2	Forged Stainless Steel Tee: ASTM A182-F304L, Dim. per ASME B16.11	Class 3000	THD, SW	40 05 23	
		Wrought Stainless Steel Tee: ASTM A403-WP304L, Dim. per ASME B16.9	Sch. 40S	THD, SW	40 05 23	
	3 thru 72	Forged Stainless Steel Half Coupling: ASTM A182-F304L, Dim. per ASME B16.11	Class 3000	FP Beveled Fillet Weld	40 05 23	
		Forged Stainless Steel Olet: ASTM A182-F304L, Dim. per MSS SP-97	Class 3000	FP Beveled Fillet Weld	40 05 23	
Grooved Coupling	All	None	—	—	—	
Flanges	1/2 thru 2-1/2	Forged Stainless Steel: ASTM A182-F304L, FF, Dim. per ASME B16.5	Class 150	WN, SO, THD	40 05 23	8
	3 thru 24	Plate Steel Backing Ring: ASTM A36, bolt pattern per ASME B16.5 with ASTM A403-WP304L stub end, Dim. per ASME B16.9	Class 150	LJ, LF	40 05 23	5, 7
		Welded Forged Stainless Steel: ASTM A182-F304L, FF, Dim. per ASME B16.5	Class 150	WN, SO	40 05 23	6, 8
		Welded Fabricated Stainless Steel: ASTM A240-304L, FF, Dim. per AWWA C228	Class SD	SO	40 05 23	6, 8
		Ductile Iron Backing Ring: ASTM A536, bolt pattern per ASME B16.5 with ASTM A403-WP304L stub end, Dim. per ASME B16.9	Class 150	LJ, LF	40 05 23	5, 7
	26 thru 72	Welded Fabricated Stainless Steel: ASTM A240-304L, FF, Dim. per AWWA C228	Class SD	SO	40 05 23	6
		Ductile Iron Backing Ring: ASTM A536, bolt pattern per ASME B16.47 with ASTM A403-WP304L stub end, Dim. per ASME B16.9	Class 150	LJ, LF		5, 7
FLG Bolts, nuts and hardware	All	Carbon Steel Bolts: ASTM A307 Gr B Carbon Steel Nuts: ASTM A563, Gr A heavy hex nuts Stainless Steel Bolts: ASTM A193 Gr B8M Stainless Steel Nuts: ASTM A194 Gr 8M	—	—	—	1 1, 2, 6, 8
Flange gaskets	3 thru 10	Viton/FKM	1/16 in Thk.	FLG	40 05 01	
	12 thru 72	Viton/FKM	1/8 in Thk.	FLG	40 05 01	
Mechanical Coupling Gaskets	All	Viton/FKM	—	—	—	

Section 40 05 02. 01 — Piping System Schedule, Process Air (Stainless Steel)

Process Service	Aeration Wash	Channel Agitation Wash						
Process Service Identifier	***AW***	***CAW***						

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged – Exposed

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Compression and Push-On Gaskets	All	None	—	—	—	
Valves	1/4 thru 2	Ball: Stainless Steel Body/Ball, 40 05 63.03	—	THD	40 05 60	
		Check: Stainless Steel Ball Cone, 40 05 65.03	—	THD	40 05 23	
	2-1/2 thru 48	Butterfly: High-Performance Resilient Seated, 40 05 64.03	—	FLG	40 05 60	10
	2-1/2 thru 30	Check: Split Disc/Double Leaf, 40 05 65.12	—	FLG	40 05 60	10
Insulation	1/2 thru 36	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium Temperature Range, Personnel Protection and Energy Conservation, Aluminum Jacket/Covers	1 in. Thk.	—	40 42 00	9
	38 thru 72	Fiberglass or Mineral Wool: ASTM C547-Type III Grade A, Medium Temperature Range, Personnel Protection and Energy Conservation, Aluminum Jacket/Covers	1 in. Thk.	—	40 42 00	9

END OF SECTION

Section 40 05 02. 17

Piping System Schedule, Natural Gas

Process Service	Natural Gas							
Process Service Identifier	***NG***							

General Requirements

A. Testing Requirements: Pressure: 50 psig. Duration: 120 min. Medium: Air or Water

B. Full-Faced flanges mated with raised face flanges are not permitted.

C. Mating flanges shall be of the same drilling pattern.

D. Threads per ASME B1.20.1.

E. Match metal alloy/grade/type for any metal welded to pipe or fittings. (Do not weld carbon steel to stainless steel. e.g. Weld Type 316L to Type 316L pipe material.)

F. For buried applications, install natural gas piping in accordance with ASTM F2620, NFPA 54 and the local plumbing codes, as applicable.

G. Transition MDPE or HDPE piping to metallic piping in the ground, exterior to the structure, in accordance with NFPA 54 requirements.

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows.
3. Provide magnetic tracer tape.
4. Extension stem and valve box required.
5. Provide with yellow exterior color or co-extruded yellow stripes per manufacturer's standard.
6. Provide Concrete Surround for pipe buried below structures.
7. Bolts and nuts with metallurgy specified in AWWA C111.
8. Ductile iron backing flanges are unlisted materials per ASME B31.1. Design and fabricate fittings per requirements for unlisted materials specified in ASME B31.1 Power Piping Code.
9. HDPE stub end adapters fused to MDPE pipe are not permitted.

Section 40 05 02. 17 — Piping System Schedule, Natural Gas

Process Service	Natural Gas							
Process Service Identifier	***NG***							

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/8 thru 1	Steel: ASTM A106, Grade B, SML, Dim. Per ASME B36.10.	Sch. 80	THD, SW	40 05 24	
	1-1/4 thru 8	Steel: ASTM A53, Grade B, SML, Dim. Per ASME B36.10.	Sch. 40	BW, FLG	40 05 24	
Lining for Pipe & Fittings	1/8 thru 8	None	—	—	—	
External Coating	All	Liquid Epoxy: Factory Applied Primer, 3-4 mils (AWWA C210), Field Applied Finish Coat per Spec. Section.	16 mils DFT	—	09 90 00	
	Valves	Manufacturer's standard primer and finish coat; shop or factory applied.	—	—	—	
Fittings	1/8 thru 2	Malleable Iron: ASTM A47 or A197, Dim. per ANSI B16.3.	Class 150	THD	40 05 24	2
		Ductile Iron: ASTM A536-Gr 65/45/12, Dim. Per ASME B16.3	Class 150	THD	40 05 24	2
		Forged Steel: ASTM A105, Dim. Per ASME B16.11	Class 3000	THD, SW	40 05 24	2
	2-1/2 thru 8	Wrought Steel: ASTM A234-WPB, Dim. per ANSI B16.9.	Sch. 40	BW, FLG	40 05 24	2
Taps	1/8 thru 2	Malleable Iron Tee: ASTM A47 or A197, Dim. per ANSI B16.3.	Class 150	THD	40 05 24	2
		Ductile Iron Tee: ASTM A536-Gr 65/45/12, Dim. Per ASME B16.3	Class 150	THD	40 05 24	2
		Forged Steel Tee: ASTM A105, Dim. per ANSI B16.11	Class 3000	THD, SW	40 05 24	2
	2-1/2 thru 8	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ANSI B16.11	Class 3000	FP Beveled Fillet Weld	40 05 24	
Grooved Coupling	All	None	—	—	—	
Flanges	1/8 thru 2	None	—	—	—	
	2-1/2 thru 8	Forged Steel: ASTM A105, FF, Dim. per ANSI B16.5	Class 150	LWN, WN, SO, SW, THD	40 05 24	
		Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 24	
FLG Bolts, nuts and hardware	All	Carbon Steel Bolts: ASTM A307 Gr A. Carbon Steel Nuts: ASTM A563, Gr A hex nuts	All	—	—	1
Flange gaskets	2-1/2 thru 8	Nitrile or Neoprene	1/16 in Thk.	FLG	40 05 01	
Mechanical Coupling Gaskets	All	None	—	—	—	
Compression and Push-On Gaskets	All	None	—	—	—	
Valves	1/8 thru 2	Ball: 316 SST body/ball, 40 05 63.03	—	THD	40 05 60	
	2-1/2 thru 8	Lubricated Plug: Steel or Gray Iron, 40 05 62.04	—	FLG	40 05 60	

Section 40 05 02. 17 — Piping System Schedule, Natural Gas

Process Service	Natural Gas							
Process Service Identifier	***NG***							

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Insulation	All	None	—	—	—	

Area Exposure Types: Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	3/4 thru 8	Medium Density Polyethylene: ASTM D2513 PE 2708, ASTM D3350-23437E, Dim. Per D2513	IPS SDR 11	BFW, FSW, EFSW	40 05 33.13	3, 5, 6
Lining for Pipe & Fittings	All	None	—	—	—	
External Coating	All	None	—	—	—	
	Valves	Coating System M-1: Per specification, field applied	—	—	09 90 00	
Fittings	3/4 thru 8	Molded Medium Density Polyethylene: ASTM D2513 PE 2708, ASTM D3350-23437E, Dim. per ASTM D3261/ASTM F1055/ASTM D2683	IPS SDR 11	BFW, EFSW, FSW	40 05 33.13	2, 3, 5
Taps	3/4 thru 8	Molded Medium Density Polyethylene Tee: ASTM D2513 PE 2708, ASTM D3350-23437E, Dim. per ASTM D3261/ASTM F1055/ASTM D2683, with reducers and MDPE to zinc plated steel MNPT transition	IPS SDR 11	BFW, FSW, EFSW	40 05 33.13	
		Medium Density Polyethylene to Epoxy Coated Carbon Steel Gas Riser Transition	IPS SDR 11	BFW, FSW, EFSW	40 05 33.13	
Grooved Coupling	All	None	—	—	—	
Flanges	3/4 thru 8	Ductile Iron Backing Flange: ASTM A536, Polypropylene coated, LJ, Dim. per ANSI B16.5 with stub end flange adapter	Class 150	BFW X FLG	40 05 33.13	7
		High Density Polyethylene Stub End Flange Adapters: ASTM D 3350-445574C/PE 4710, Dim. per ASTM D3261	IPS SDR 11	—	40 05 33.13	9

Section 40 05 02. 17 — Piping System Schedule, Natural Gas

Process Service	Natural Gas							
Process Service Identifier	***NG***							

Area Exposure Types: Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
FLG Bolts, nuts and hardware	All	Non-Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Type 3, Class C or Class D with Carbon Steel Nuts: ASTM 536-Gr C3, Class C or	—	—	—	1, 7
		Carbon Steel Bolts: ASTM A307-Gr A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with Carbon Steel Nuts: ASTM A563-Gr A hex nuts with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal.	—	—	—	1
Flange gaskets	3/4 thru 8	Nitrile or Neoprene	1/16 in Thk	FLG	40 05 01	
Mechanical Coupling Gaskets	All	None	—	—	—	
Compression and Push-On Gasket	All	None	—	—	—	
Valves	1/8 thru 2	Ball Valve: 316 SST body/ball, 40 05 63.03	—	THD	40 05 60	4
	2-1/2thru 8	Lubricated Plug Valve: 40 05 62.04	—	FLG	40 05 60	4
Insulation	All	None	—	—	—	

END OF SECTION

Section 40 05 02. 23

Piping System Schedule, Potable Water

Process Service	Filtered Water	Hot Water Supply / Return	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***HWS / HWR***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

General Requirements

A. **Testing Requirements: Pressure: 200 psig. Duration: 60 min. Medium: Water**

B. Full-Faced flanges mated with raised face flanges are not permitted.

C. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

D. Threads per ASME B1.20.1.

E. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel. Weld Type 316L to Type 316L pipe material.)

F. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Weld Threadolet or Half Coupling prior to installing lining and coating.
5. Provide concrete surround or encasement for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. Provide magnetic tracer tape.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. RJC (Ring Joint Coupling): Victaulic Vic-Ring Coupling or Approved Equal with welded pipe shoulders or ring adapters
11. Provide AWWA standard 2-inch square nut operator, extension stem, and valve box for buried valves.
12. Hard, drawn, furnished in straight lengths.
13. Provide annealed tube for flared fittings. Furnished in straight lengths or coils.
14. 3/8-inch-thick wall required for installation of CGRV on 24-inch pipe.
15. PGRV (Proprietary Groove): Victaulic Advanced Groove System or Approved Equal.
16. Provide rigid couplings for 3-inch thru 12-inch except pipe installed on pipe racks (pipe/utility tunnels or chases) or for connections to pumps and blowers.
17. NSF 61 certified.

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

18. Coating may be omitted for pipe encased in concrete or grout.
19. HPEG (HDPE Plain End with Gripping Teeth): Victaulic Style 995N, Victaulic Style 905, or Approved Equal.
20. HGRV (HDPE Groove Coupling): Victaulic Style 908 or Approved Equal.
21. In addition to the design pressure and test pressure indicated in this schedule, surge pressure and pipe bedding conditions for concrete cylinder pipe are specified in 40 05 39.13 and 40 05 39.16.
22. Wall thickness and pressure rating as calculated per AWWA Manual M11 will match or exceed that of connecting piping. Increase wall thickness as necessary.

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/4 thru 1/2	Copper Tube: ASTM B88, Drawn	Type L	FLRD, CPRSN	40 05 17	13
	1/2 thru 3	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	Sch. 80	THD, FLG, SLV	40 05 31.13	
		Copper Tube: ASTM B88, Drawn	Type L	SLDR	40 05 17	12
		Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	Sch. 40	THD	40 05 24	
		Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19	40S	BW, THD	40 05 23	
	4 thru 12	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	Sch. 40	CGRV, RGRV, FLG	40 05 24	
	14 thru 24	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	Sch. 40 or Std. Wt.	CGRV, RGRV, PGRV, FLG	40 05 24	15
		Steel: AWWA C200	5/16 in. Thk.	CGRV, RGRV, PGRV, FLG	40 05 24	14, 15
	26 thru 48	Steel: AWWA C200	5/16 in. Thk.	PGRV, BW, FLG	40 05 24	15
	4 thru 48	Ductile Iron: AWWA C151	Thk. Class 53	CGRV, FLG	40 05 19	
	14 thru 48	Ductile Iron: AWWA C151 with shouldered end	Pr. Class 150	PGRV, RJC	40 05 19	10, 15
Lining for Pipe & Fittings	1/4 thru 3	None	—	—	—	
	Steel, 4 thru 48	Cement Mortar: Factory Applied, AWWA C205, NSF 61 certified	Thk. per Std.	—	40 05 24	
		Liquid Epoxy: Factory Applied, AWWA C210, NSF 61 certified	16 mils DFT	—	40 05 24	
		Fusion-Bonded Epoxy: Factory Applied, AWWA C213, NSF 61 certified	12 mils CFT	—	40 05 24	
		Polyurethane: Factory Applied, AWWA C222, NSF 61 certified	Thk. per Std.	—	40 05 24	
	Ductile Iron, All	Cement Mortar: AWWA C104, NSF 61 certified, Factory Applied	Thk, per Std.	—	40 05 19	

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
		Fusion Bonded Epoxy Lining and Coating: AWWA C116, NSF 61 certified, Factory Applied	Thk, per Std.	—	40 05 19	
External Coating	Steel, All	Liquid Epoxy: Factory Applied, AWWA C210	16 mils DFT	—	40 05 24	
		Three Coat Zinc/Epoxy/Urethane: Factory Applied, AWWA C218	16 mils DFT	—	40 05 24	
		Fusion-Bonded Epoxy: Factory Applied, AWWA C213	12 mils CFT	—	40 05 24	
		Polyurethane: Factory Applied, AWWA C222	Thk. per Std.	—	40 05 24	
	Ductile Iron, All	Polyamidoamine Epoxy Primer: Manufacturer's Standard, Factory Applied	8 mils DFT	—	40 05 19	
		Fusion Bonded Epoxy Lining and Coating: AWWA C1116, Factory Applied	Thk. per Std.	—	40 05 19	
	Valves	Epoxy: Manufacturer's standard, primer and finish coat, Factory Applied	—	—	—	
Fittings	1/4 thru 1/2	Cast Copper Alloy (Brass or Bronze): Material and dim. per ANSI B16.26	—	FLRD	40 05 17	
		Copper or Bronze: Swagelok, Gyrolok, Hylok, or approved equal	—	CPRSN	40 05 17	
	1/2 thru 3	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	Sch. 80	THD, FLG, SLV	40 05 31.13	
		Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3.	Class 150	THD	40 05 24	
		Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Wrought Copper and Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.22	—	SLDR	40 05 17	
		Cast Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.18	—	SLDR	40 05 17	
		Forged Stainless Steel: ASTM A182-F304, Dim. per ASME B16.11	Class 3000	THD	40 05 23	
		Cast Stainless Steel: ASTM A351-CF8, Dim. per ASME B16.3	Class 150	THD	40 05 23	
	4 thru 24	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	150 psi	CGRV	40 05 24	2
		Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	CGRV	40 05 24	2
		Wrought Steel Grooved End: ASTM A234-WPB, r/D dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.	Sch. 40 or Std. Wt.	CGRV	40 05 24	2
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or Std. Wt.	CGRV	40 05 24	3
		Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9	Sch. 40 or Std. Wt.	FLG	40 05 24	2
	14 thru 24	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	PGRV	40 05 24	2
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or Std. Wt.	PGRV	40 05 24	3

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
	26 thru 48	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	PGRV	40 05 24	2, 15
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or Std. Wt.	PGRV	40 05 24	3, 15
		Fabricated Steel: Materials per AWWA C200, Dim. per AWWA C208	5/16 in. Thk.	BW, FLG	40 05 24	3
		Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9	Sch. 40 or Std. Wt.	BW, FLG	40 05 24	2
	4 thru 36	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	150 psi	CGRV	40 05 19	
	4 thru 48	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	150 psi	FLG	40 05 19	
	14 thru 48	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	PGRV, RJC	40 05 19	2, 10, 15
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	150 psi	PGRV, RJC	40 05 19	3, 10, 15
Taps	1/4 thru 1/2	Cast Copper Alloy Tee (Brass or Bronze): Material and dim. per ANSI B16.26	—	FLRD	40 05 17	
		Copper or Bronze Tee: Swagelok, Gyrolok, Hylok, or approved equal	—	CPRSN	40 05 17	
	1/2 thru 3	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	Sch. 80	SLV	40 05 31.13	
		Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	Class 3000	THD, SW	40 05 24	
		Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Wrought Copper and Copper Alloy Tee (Brass or Bronze): Materials and Dim. per ASME B16.22	—	SLDR	40 05 17	
		Cast Copper Alloy Tee (Brass or Bronze): Materials and Dim. per ASME B16.18	—	SLDR	40 05 17	
		Forged Stainless Steel Tee: ASTM A182-F304, Dim. per ASME B16.11	Class 3000	THD	40 05 23	
		Cast Stainless Steel Tee: ASTM A351-CF8, Dim. per ASME B16.3	Class 150	THD	40 05 23	
	4 thru 48	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	Class 3000	FP Beveled Fillet Weld	40 05 24	4
	Ductile Iron, All	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	Sch. 40	THD	40 05 19	7
Grooved Coupling	4 thru 24	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV, RGRV	40 05 24	16
		Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV, RGRV	40 05 24	16

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
	14 thru 48	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim	150 psi	PGRV	40 05 24	15
	4 thru 36	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV	40 05 19	16
		Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV	40 05 19	
	14 thru 48	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim	150 psi	PGRV, RJC	40 05 19	15
Flanges	1/2 thru 3	PVC: ASTM A1784-Class 12454-B, Dim. per ASME B16.5	Class 150	SLV x FLG	40 05 31.13	
	4 thru 24	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	Class 150	LWN, WN, SO	40 05 24	
		Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 24	
	26 thru 48	Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 24	
	Ductile Iron, All	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	250 psi	FLG	40 05 19	
FLG Bolts, nuts and hardware	All	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	All	—	—	1
Flange gaskets	1/8 thru 10	Nitrile or Neoprene: NSF 61 certified	1/16 in Thk.	FLG	40 05 01	17
	12 thru 48	Nitrile or Neoprene: NSF 61 certified	1/8 in Thk.	FLG	40 05 01	17
Mechanical Coupling Gaskets	4 thru 48	EPDM: NSF 61 certified	—	CGRV, RGRV, PGRV	40 05 01	17
Compression and Push-On Gaskets	All	None	—	—	—	
Valves	1/4 thru 3	Ball: Bronze Body/Ball, 40 05 63.02	—	THD	40 05 60	17
		Globe: Bronze, 40 05 66.01	—	THD	40 05 60	17
		Swing Check: Bronze 40 05 65.01	—	THD	40 05 60	17
	4 thru 48	Butterfly: AWWA C504, Class 150B, 40 05 64.05	—	FLG	40 05 60	17
		Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16	—	FLG	40 05 60	17
Insulation	1/4 thru 8	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	1 in. Thk		40 42 00	
	10 thru 48	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	1 in. Thk		40 42 00	

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/2 thru 3	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	Sch. 80	THD, FLG, SLV	40 05 31.13	5, 8
		High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901	IPS DR 17	See Drawings	40 05 33.13	5, 8
		Copper Tube: ASTM B88	Type K	SLDR	40 05 17	5, 12
		Steel: ASTM A53, galvanized, Gr B, Type E, Dim. Per ASME B36.10	Sch. 40	THD	40 05 24	5,
		Stainless Steel: ASTM A312-TP304L, WLD or SML, Dim. Per ASME B36.19.	Sch. 40S	THD	40 05 23	5
	4 thru 54	High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906	IPS DR 17	FLG, BFW, EFSW, HPEG, HGRV	40 05 33.13	5, 8, 19, 20
	4 thru 12	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	Sch. 40	CGRV, RGRV, FLG	40 05 24	
	14 thru 24	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	Sch. 40 or Std. Wt.	CGRV, RGRV, PGRV, FLG	40 05 24	15
		Steel: AWWA C200	5/16 in. Thk.	CGRV, RGRV, PGRV, FLG	40 05 24	14, 15
	4 thru 12	Ductile Iron: AWWA C151	Pr. Class 350	RMJ per Drawings	40 05 19	5, 6, 18
	14 thru 48	Ductile Iron: AWWA C151	Pr. Class 250	RMJ, RPO, FLG	40 05 19	5, 6, 18
	4 thru 36	Ductile Iron: AWWA C151	Thk. Class 53	CGRV	40 05 19	5, 18
	26 thru 42	Fabricated Steel: Material and Dim. per AWWA C200	5/16 in. Thk.	DLW, RBAS, FLG, PGRV	40 05 24	5, 18
	44 thru 48	Fabricated Steel: Material and Dim. per AWWA C200	3/8 in. Thk.	DLW, RBAS, FLG, PGRV	40 05 24	5, 18
	16 thru 48	Prestressed Concrete Cylinder: AWWA C301	150 psig	FLG, HC, SR	40 05 39.13	5, 21
	16 thru 48	Bar Wrapped Concrete Cylinder: AWWA C303	150 psig	FLG, HC, SR	40 05 39.16	5, 21
Lining for Pipe & Fittings	1/2 thru 3	None	—	—	—	
	HDPE, All	None	—	—	—	
	Ductile Iron, 4 thru 48	Cement-Mortar: AWWA C104, NSF 61 certified	—	—	40 05 19	
	Steel, 4 thru 48	Cement Mortar: AWWA C205, NSF 61 certified, Factory Applied	Thk. per Std.	—	40 05 24	

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
		Liquid Epoxy: AWWA C210, NSF 61 certified, Factory Applied	16 mils DFT	—	40 05 24	
		Fusion-Bonded Epoxy: AWWA C213, NSF 61 certified, Factory Applied	12 mils CFT	—	40 05 24	
		Polyurethane: AWWA C222, NSF 61 certified, Factory Applied	Thk. per Std.	—	40 05 24	
	Concrete Cylinder, All	None	—	—	—	
External Coating	PVC, 1/2 thru 3	None	—	—	—	
	Copper, SST and Galv. Steel, 1/2 thru 3	Pipe Wrap Tape: Polyethylene or PVC tape, Shop or Field Applied	2 wraps /layers	—	—	
	HDPE, All	None	—	—	—	
	Ductile Iron, 4 thru 48	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied	Thk. per Std	—	40 05 19	
		Polyethylene Encasement: AWWA C105, Field Installed	Thk. per Std	—	40 05 19	
		Zinc Coating with Asphaltic Topcoat: Per Specification, Factory Applied	—	—	40 05 19	
		V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed	—	—	40 05 19	
		Fusion Bonded Epoxy Lining and Coating: AWWA C116, NSF 61 certified, Factory Applied	Thk. per Std	—	40 05 19	
	Steel 4 thru 48	Tape Wrap: AWWA C209 and AWWA C214, Factory Applied	80 mils	—	40 05 24	
		Cement Mortar: AWWA C205, NSF 61 certified, Factory Applied	Thk. per Std.	—	40 05 24	
		Liquid Epoxy: AWWA C210, Factory Applied	16 mils DFT	—	40 05 24	
		Fusion-Bonded Epoxy: AWWA C213, Factory Applied	12 mils CFT	—	40 05 24	
		Polyurethane: AWWA C222, Factory Applied	Thk. per Std.	—	40 05 24	
	Concrete Cylinder, All	None	—	—	—	
	Valves	Epoxy: Manufacturer's standard, primer and finish coat, Factory Applied	—	—	—	
Fittings	1/2 thru 3	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	Sch. 80	THD, FLG, SLV	40 05 31.13	2, 5, 8, 18
		HDPE Molded Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261/ASTM F1055/ASTM D2683	IPS SDR 11	FLG, FSW, EFSW, BFW, HPEG	40 05 33.13	5, 8, 19

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
		Wrought Copper and Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.22	—	SLDR	40 05 17	5, 18
		Cast Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.18	—	SLDR	40 05 17	5, 18
		Malleable Iron: ASTM A197, Dim. per ASME B16.3, galvanized	Class 150	THD	40 05 24	5
		Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	5
		Forged Stainless Steel: ASTM A182-F304, Dim. per ASME B16.11	Class 3000	THD	40 05 23	5
		Cast Stainless Steel: ASTM A351-CF8, Dim. per ASME B16.3	Class 150	THD	40 05 23	5
	4 thru 12	HDPE Molded Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261/ASTM F1055/ASTM D2683	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	40 05 33.13	2, 5, 21, 22
		HDPE Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D 3035/AWWA C901	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	40 05 33.13	2, 5, 19, 20
	14 thru 20	HDPE Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	IPS SDR 13.5	FLG, BFW, HPEG, HGRV	40 05 33.13	3, 5, 19, 20
		HDPE Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906	IPS SDR 17	FLG, BFW, HPEG, HGRV	40 05 33.13	2, 5, 19, 20
	22 thru 36	HDPE Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	IPS SDR 13.5	FLG, BFW, HGRV	40 05 33.13	3, 5, 20
	4 thru 24	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	150 psi	CGRV	40 05 24	2, 5, 18
		Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	CGRV	40 05 24	2, 5, 18
		Wrought Steel Grooved End: ASTM A234-WPB, r/D dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.	Sch. 40 or Std. Wt.	CGRV	40 05 24	2, 5, 18
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or Std. Wt.	CGRV	40 05 24	3, 5, 18
		Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9	Sch. 40 or Std. Wt.	FLG	40 05 24	2, 5, 18
	14 thru 24	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	150 psi	PGRV	40 05 24	2, 5, 18
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or Std. Wt.	PGRV	40 05 24	3, 5, 18
	4 thru 36	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	250 psi	CGRV	40 05 19	5

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
	4 thru 48	Ductile Iron: AWWA C110 or AWWA C153	250 psi	RMJ, FLG, RPO	40 05 19	5, 6
	26 thru 42	Fabricated Steel: Materials per AWWA C200, Dim. per AWWA C208	5/16 in. Thk.	DLW, FLG, RBAS, PGRV	40 05 24	3, 5, 22
	44 thru 48	Fabricated Steel: Materials per AWWA C200, Dim. per AWWA C208	3/8 in. Thk.	DLW, FLG, RBAS, PGRV	40 05 24	3, 5, 22
	16 thru 72 Concrete Cylinder	Fabricated Steel: AWWA C301 and AWWA M9 with concrete lining and coating.	150 psig	FLG, HC, SR	40 05 39.13	3, 5, 21
	16 thru 72 Concrete Cylinder	Fabricated Steel: AWWA C303 and AWWA M9 with concrete lining and coating.	150 psig	FLG, HC, SR	40 05 39.16	3, 5, 21
Taps	1/2 thru 3	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	Sch. 80	SLV	40 05 31.13	
		Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG	40 05 33.13	19
		Wrought Copper and Copper Alloy (Brass or Bronze) Tee: Materials and Dim. per ASME B16.22	—	SLDR	40 05 17	
		Cast Copper Alloy (Brass or Bronze) Tee: Materials and Dim. per ASME B16.18	—	SLDR	40 05 17	
		Malleable Iron Tee: ASTM A197, Dim. per ASME B16.3, galvanized	Class 150	THD	40 05 24	
		Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Forged Stainless Steel Tee: ASTM A182-F304, Dim. per ASME B16.11	Class 3000	THD	40 05 23	
		Cast Stainless Steel Tee: ASTM A351-CF8, Dim. per ASME B16.3	Class 150	THD	40 05 23	
	HDPE, 4 thru 12	Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	40 05 33.13	19, 20
	HDPE, 14 thru 54	Electrofusion Branch Saddle Tap: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F1055, with reducers and HDPE to 316 Stainless Steel MNPT transition	IPS SDR 17	EFSW, FSW	40 05 33.13	
	Ductile Iron, 4 thru 48	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	Sch. 40	THD	40 05 19	7
	Steel, 4 thru 48	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	Class 3000	FP Beveled Fillet Weld	40 05 24	4

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
	Concrete Cylinder, All	None	—	—	—	
Grooved Coupling	4 thru 36	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV	40 05 19	
	4 thru 24	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	150 psi	CGRV, RGRV	40 05 24	16
	14 thru 48	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim	150 psi	PGRV	40 05 24	15
	8 thru 36	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per manufacturer's standard	150 psi	HGRV	40 05 33.13	20
	2 thru 20	Flexible Coupling: ASTM A536 Gr 65/45/12, Gripping Teeth per manufacturer's standard	150 psi	HPEG	40 05 33.13	19
Flanges	1/2 thru 3	PVC: ASTM A1784-Class 12454-B, Dim. per ASME B16.5	Class 150	SLV x FLG	40 05 31.13	
	HDPE, All	Ductile Iron Backing Ring: ASTM A536, Polypropylene coated, LJ, Dim. per ANSI B16.5 with stub end flange adapter with Stub End Flange Adapters: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261	Class 150	BFW x FLG IPS SDR 17	40 05 33.13	
	Ductile Iron, 4 thru 48	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1 Class 125	250 psig	THD	40 05 19	6
	Steel, All	Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 24	
	Concrete, Cylinder All	Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 39.13	
	Concrete, Cylinder All	Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 39.16	
FLG Bolts, nuts and hardware	All	Non-Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D	—	—	—	1, 9
		Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal, with Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	—	—	1
Flange gaskets	1/2 thru 10	Nitrile or Neoprene	1/16 in Thk	FLG	40 05 01	17
	12 thru 48	Nitrile or Neoprene	1/8 in Thk	FLG	40 05 01	17

Section 40 05 02. 23 — Piping System Schedule, Potable Water

Process Service	Filtered Water	Settled Water	Potable Water	Tepid Water	Filter Influent	Recycle Water	Raw Water	
Process Service Identifier	***FW***	***SW***	***PW***	***TWP***	***FI***	***RCW***	***RW***	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Mechanical Coupling Gaskets	4 thru 48	EPDM	—	CGRV, HPEG, HGRV	40 05 01	17
Compression and Push-On Gasket	4 thru 48	Neoprene or Nitrile	—	RMJ, RPO, RBAS, HC, SR	40 05 01	17
Valves	1/2 thru 3	Ball: Bronze Body/Ball, 40 05 63.02	—	THD	40 05 60	11, 17
		Gate: Bronze, Non-Rising Stem, 40 05 61.11	—	THD	40 05 60	11, 17
	4 thru 48	Butterfly: AWWA C504, Class 150B, 40 05 64.05	—	FLG	40 05 60	6, 11, 17
		Gate: Ductile Iron, Non-Rising Stem, 40 05 61.17	—	FLG	40 05 60	6, 11, 17
	14 thru 48	Butterfly: Buried Service, AWWA C504, Class 150 B, 40 05 64.21	—	FLG	40 05 60	6, 17
Insulation	All	None	—	—	—	

Buried (5ft Outside Building – Yard Piping):
See Civil Yard Piping Plans for Materials and Specification References

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Section 40 05 02. 25

Piping System Schedule, Hydronic Systems

Process Service	Hot Water Return	Hot Water Supply						
Process Service Identifier	***HWR***	***HWS***						

General Requirements

A. Testing Requirements: Pressure: 75 psig. Duration: 120 min. Medium: Water

B. Provide manual air vents at the high points and drains provided at the low points of each reach of pipeline as specified in section 40 05 06.

C. Full-Faced flanges mated with raised face flanges are not permitted.

D. Mating flanges shall be of the same drilling pattern.

E. Threads per ASME B1.20.1.

F. Match metal alloy/grade/type for any metal welded to pipe or fittings. (Do not weld carbon steel to stainless steel. e.g. Weld Type 316L to Type 316L pipe material.)

G. Fittings shall match material, ends and wall thickness of pipe.

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows.
3. Hard Drawn, finished in straight lengths
4. Repair prime coat at welds and other locations where the prime coat has been damaged.
5. Furnish threaded adapters at connections to valves.

Section 40 05 02. 25 — Piping System Schedule, Hydronic Systems

Process Service	Hot Water Return	Hot Water Supply						
Process Service Identifier	***HWR***	***HWS***						

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1 thru 2-1/2	Copper Tube: ASTM B88, drawn.	Type L	SLDR	40 05 17	3
		Steel: ASTM A53 Gr B, Type E or Type S, Dim. per ASME B36.10	Sch. 40	THD	40 05 24	
	3 thru 24	Steel: ASTM A53, Gr B, Type E or Type S, Dim per ASME B36.10	Sch. 40	BW, FLG, RGRV, CGRV	40 05 24	
Lining for Pipe & Fittings	All	None	—	—	—	
External Coating	Copper, All	None	—	—	—	
	Steel, All	Factory or shop installed red oxide primer	—	—	—	4
	Valves	Manufacturer's standard coating	—	—	—	
Fittings	Copper, 1 thru 2-1/2	Wrought Copper and Copper Alloy: Material and Dim. Per ASME B16.22	—	SLDR	40 05 17	
		Cast Copper Alloy: Materials and Dim. Per ASME B16.18	—	SLDR	40 05 17	
	Steel, 1 thru 2-1/2	Malleable Iron: ASTM A47 or A197, Dim. per ASME B16.3	Class 150	THD	40 05 24	2
		Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per ASME B16.3	Class 150	THD	40 05 24	2
	3 thru 24	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	Class 150	CGRV	40 05 24	2
		Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	M or E Pipe	CGRV	40 05 24	2
		Wrought Steel Grooved End: ASTM A234-WPB, r/D dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.	Sch. 40 or STD	CGRV, RGRV	40 05 24	2
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40 or STD	CGRV, RGRV	40 05 24	2
		Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9.	Sch. 40 or STD	BW, FLG	40 05 24	2
Taps	Copper, 1 thru 2-1/2	Wrought Copper or Bronze Tee: Material and Dim. per ANSI B16.22 Reducing bushings as necessary.	—	SLDR x THD	40 05 17	
		Cast Copper Alloy Tee: Materials and Dim. Per ASME B16.18	—	SLDR	40 05 17	
	Steel, 1 thru 2-1/2	Malleable Iron Tee: ASTM A47 or A197, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Ductile Iron Tee: ASTM A536-Gr 65/45/12, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Forged Steel Tee: ASTM A105, Dim. per ASME B16.11	Class 3000	THD	40 05 24	
	3 thru 24	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ANSI B16.11	Class 3000	FP Beveled Fillet Weld	40 05 24	

Section 40 05 02. 25 — Piping System Schedule, Hydronic Systems

Process Service	Hot Water Return	Hot Water Supply						
Process Service Identifier	***HWR***	***HWS***						

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Grooved Coupling	1 thru 2-1/2	None	—	—	—	
	3 thru 24	Rigid Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	M or E Pipe	CGRV, RGRV	40 05 24	
Flanges	3 thru 24	Forged Steel: ASTM A105, FF, Dim. per ANSI B16.5	Class150	LWN, WN, SO	40 05 24	
		Plate Steel: FF, Material and Dim. per AWWA C207	Class D	SO	40 05 24	
FLG Bolts, nuts and hardware	All	Carbon Steel Bolts: ASTM A307-Gr A Carbon Steel Nuts: ASTM A563-Gr A hex nuts	All	—	—	1
Flange gaskets	3 thru 10	Viton/FKM	1/16 in Thk.	FLG	40 05 01	
	12 thru 24	Viton/FKM	1/8 in Thk.	FLG	40 05 01	
Mechanical Coupling Gaskets	1 thru 2-1/2	None	—	—	—	
	3 thru 24	EPDM: Victaulic Grade EHP, Gruvlok, Grade EP, or approved equal	All	CGRV, RGRV	40 05 01	
Compression and Push-On Gaskets	All	None	All	—	—	
Valves	1 thru 2-1/2	Ball Valve: Bronze Body/Ball, 40 05 63.02	—	THD	40 05 60	5
		Swing Check: Bronze 40 05 65.01	—	THD	40 05 60	5
	1 thru 6	Manual Balancing Valve: per Specification	—	THD, FLG	23 21 16	5
	3 thru 12	Pump Discharge (Triple Duty) Valve: per Specification	—	FLG	23 21 16	
	3 thru 24	Butterfly Valve: 40 05 64.01	—	FLG	40 05 60	
		Swing Check Valve: 40 05 65.08	—	FLG	40 05 60	
Insulation	1 thru 24	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium Temperature Range, Energy Conservation, Aluminum Jacket/Covers.	1 in. Thk.	—	40 42 00	

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Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Surround for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. No lining or coating for Concrete Cylinder Pipe.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. BW (butt weld) connections/joints not permitted for 14-inch through 24 inch pipe.
11. Provide square nut operator, extension stem, and valve box for buried valves.
12. 3/8 inch thick wall required for installation of CGRV on 24-inch pipe.

Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	3 thru 12	Sch. 40	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
	14 thru 24	Sch. 20	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
		5/16 in. Thk.	CGRV, RGRV, FLG	Steel: AWWA C200		12
	26 thru 48	5/16in. Thk.	PGRV, BW, FLG	Steel: AWWA C200	40 05 24	
Lining for Pipe & Fittings	1/8 thru 3	—	—	None	—	
	4 thru 48	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210, NSF 61 certified	40 05 24	
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
Fittings	1/8 thru 2-1/2	Class 150	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3	40 05 24	
		Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
	3 thru 24	Class 150	CGRV, RGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	2
		M or E Pipe	CGRV, RGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		
		Sch. 40 or Std. Wt.	CGRV, RGRV	Wrought Steel Grooved End: ASTM A234-WPB, r/D dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.		
		Sch. 40 or Std. Wt.	CGRV, RGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		
		Sch. 40 or Std. Wt.	FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		

Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Fittings (continued)	26 thru 48	M or E Pipe	PGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	40 05 24	2
		Sch. 40 or Std. Wt.	PGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3
		1/4 in. Thk.	BW, FLG	Fabricated Steel: AWWA C200, Dim. per AWWA C208		3, 10
		Sch. 40 or Std. Wt.	BW, FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		2, 10
Taps	1/2 thru 2-1/2	Class 3000	THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
		Class 150	THD	Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 150	THD	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3		
	3 thru 48	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4
Grooved Coupling	3 thru 24	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	26 thru 48	M or E Pipe	PGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim. Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	
Flanges	4 thru 24	Class 150	LWN, WN, SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	40 05 24	
		Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207		
	26 thru 48	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 48	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 48	—	CGRV, RGRV	EPDM	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	
Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02 Globe: Bronze, 40 05 66.01 Swing Check: Bronze 40 05 65.01	40 05 60	
	3 thru 48		FLG	Butterfly: AWWA C504, Class 150B, 40 05 64.05	40 05 60	

Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
				Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16		
Insulation	1/4 thru 8	1 in. Thk		Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 48	1 in. Thk		Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	

Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	5
	4 thru 12	Pr. Class 350	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	14 thru 48	Pr. Class 250	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	4 thru 36	Class 53	CGRV	Ductile Iron: AWWA C151	40 05 19	5
	24 thru 48	250 psi	FLG, RBAS	Prestressed Concrete Cylinder: AWWA C301	40 05 39.13	5
Lining for Pipe & Fittings	1/2 thru 3	—	—	None	—	
	4 thru 48	—	—	Cement-Mortar: AWWA C104, NSF 61 certified	40 05 19	8
External Coating	1/2 thru 3	—	—	None	—	
	4 thru 48	Thk. per Std — — —	—	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied Polyethylene Encasement: AWWA C105, Field Installed Zinc Coating with Asphaltic Top Coat: Per Specification, Factory Applied V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed	40 05 19	8
	Valves	—	—	Coating System M-1: Per specification, Field Applied	09 90 00	
Fittings	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	5
	4 thru 12	350 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	14 thru 36	250 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	4 thru 24	350 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	30 thru 48	250 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	24 thru 48	3/8 in. Thk.	FLG, RBAS	Fabricated Steel: AWWA C200, Dim. per AWWA C208, cement mortar lined and coated per AWWA C205	40 05 39.13	3, 5, 6
Taps	1/2 thru 3	Sch. 80	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	
	4 thru 48	Sch. 40	THD	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 19	7
Grooved Coupling	4 thru 36	M or E Pipe	CGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	40 05 19	
Flanges	1/2 thru 3	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
	4 thru 48	250 psig	FLG	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	40 05 19	6

Schedule 40 05 02.27 - Plant Utility Water, Low Pressure

Process Service	Utility Water No. 1	Utility Water No. 2			
Process Service Identifier	UW1	UW2			

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
FLG Bolts, nuts and hardware	All	—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 9 1 1 1
Flange gaskets	1/2 thru 10	1/16 in Thk	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 48	1/8 in Thk	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	4 thru 48	—	CGRV	EPDM	40 05 01	
Compression and Push-On Gasket	4 thru 48	—	RMJ, RPO, RBAS	Neoprene or Nitrile	40 05 01	
Valves	1/2 thru 3	—	THD THD	Ball: Bronze Body/Ball, 40 05 63.02 Gate: Bronze, Non-Rising Stem, 40 05 61.11	40 05 60	11
	4 thru 48	—	FLG	Butterfly: AWWA C504, Class 150B, 40 05 64.05	40 05 60	6, 11
Insulation	All	—	—	None	—	

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Surround for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. No lining or coating for HDPE Pipe.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. BW (Butt Weld) and RJC (Ring Joint Coupling) connections/joints not permitted for 14-inch through 24 inch pipe.
11. Install plug valve with seat at the inlet or upstream connection to piping.
12. Provide square nut operator, extension stem, and valve box for buried valves.
13. PGRV (Proprietary Groove): Victaulic Advanced Groove System or Approved Equal
14. RJC (Ring Joint Coupling): Victaulic Vic-Ring Coupling or Approved Equal with welded pipe shoulders or ring adapters
15. Where specified pipe wall thickness (Rating) is insufficient for cut grooves, provide shouldered ends, ring adapters, or increase pipe wall thickness as necessary for installation of cut grooves.
16. Provide rigid couplings except for pipe installed on pipe racks in below pipe/utility tunnels or chases.
17. HPEG (HDPE Plain End with Gripping Teeth): Victaulic Style 995N, Victaulic Style 905, or Approved Equal.

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

18. HGRV (HDPE Groove Coupling): Victaulic Style 908 or Approved Equal.

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	3 thru 12	Sch. 40 or STD	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
	14 thru 24	Sch. 20	CGRV, RGRV, PGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	13
		1/4 in. Thk.	CGRV, RGRV, PGRV, FLG,	Steel: AWWA C200		13, 15
	26 thru 48	5/16 in. Thk.	PGRV	Steel: AWWA C200	40 05 24	13
		1/4 in. Thk.	BW, FLG, RJC	Steel: AWWA C200		14
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG, PGRV, RJC	Steel: AWWA C200	40 05 24	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 72	Thk. per Std.	—	Cement Mortar: Factory Applied, AWWA C205, NSF 61 certified	40 05 24	
		16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210, NSF 61 certified		
		12 mils CFT	—	Fusion-Bonded Epoxy: Factory Applied, AWWA C213, NSF 61 certified		
		Thk. per Std.	—	Polyurethane: Factory Applied, AWWA C222, NSF 61 certified		
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
		16 mils DFT	—	Three Coat Zinc/Epoxy/Urethane: Factory Applied, AWWA C218		
		Thk. per Std.	—	Polyurethane: Factory Applied, AWWA C222		
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
Fittings	1/8 thru 2-1/2	Class 150	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3	40 05 24	
		Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
Fittings (continued)	3 thru 24	Class 150	CGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	
		M or E Pipe	CGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		
		Sch. 40 or STD	CGRV, RGRV	Wrought Steel Grooved End: ASTM A234-WPB, r/D Dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.		
		Sch. 40 or STD	CGRV, RGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
		Sch. 40 or STD	FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		
	14 thru 48	M or E Pipe	PGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	40 05 24	13
		Sch. 40 or STD	PGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3, 13
		1/4 in. Thk.	BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208		3, 10, 14
		Sch. 40 or STD	BW, FLG, RJC	Wrought Steel: ASTM A234-WPB, r/D Dim. per ASME B16.9, grooved tangents for RJC Conn./Joints		2, 10, 14
	50 thru 72	3/8 in. Thk.	PGRV, DLW, BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Taps	1/2 thru 2-1/2	Class 3000	THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
		Class 150	THD	Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 150	THD	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3		
	3 thru 72	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4
Grooved Coupling	3 thru 12	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	16
	14 thru 24	M or E Pipe	CGRV, RGRV	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 72	M or E Pipe	PGRV, RJC	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	10
Flanges	4 thru 24	Class 150	LWN, WN, SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	40 05 24	
		Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207		
	26 thru 72	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	—	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	
Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	
				Swing Check: Bronze 40 05 65.01		

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
	3 thru 60		FLG	Plug: AWWA C517, Standard Port, 40 05 62.01 Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16	40 05 60	11
Insulation	3/8 thru 8	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 72	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 3	Sch. 80 IPS DR 17	THD, FLG, SLV FLG, FSW, EFSW, BFW, HPEG	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785 High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901	40 05 31.13 40 05 33.13	5 5, 17
	4 thru 12	Pr. Class 350	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	14 thru 54	Pr. Class 250	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	4 thru 36	Class 53	CGRV	Ductile Iron: AWWA C151	40 05 19	5
	4 thru 60	IPS DR 17	FLG, BFW, HPEG, HGRV	High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906	40 05 33.13	5, 17, 18
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Lining for Pipe & Fittings	1/2 thru 3	—	—	None	—	7
	Ductile Iron, All	40 mils	—	Ceramic Epoxy: Per Specification, Factory Applied Cement Mortar: AWWA C104, NSF 61 certified, Factory Applied	40 05 19	
	HDPE, All	—	—	None		8
	Steel, All	Thk. per Std. 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Cement Mortar: AWWA C205, NSF 61 certified, Factory Applied Liquid Epoxy: AWWA C210, NSF 61 certified, Factory Applied Fusion-Bonded Epoxy: AWWA C213, NSF 61 certified, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
External Coating	1/2 thru 3	—	—	None	—	
	HDPE, All	—	—	None		8
	Ductile Iron, All	Thk. per Std. Thk. per Std. — —	— — — —	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied Polyethylene Encasement: AWWA C105, Field Installed Zinc Coating with Asphaltic Top Coat: Per Specification, Factory Applied V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed	40 05 19	
	Steel, All	80 mils 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Tape Wrap: AWWA C209 and AWWA C214, Factory Applied Liquid Epoxy: AWWA C210, Factory Applied Fusion-Bonded Epoxy: AWWA C213, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
	Valves	—	—	Coating System M-1: Per specification, Field Applied	09 90 00	
Fittings	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	5

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
	4 thru 12	350 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	14 thru 36	250 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	4 thru 24	350 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	30 thru 54	250 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	1/2 thru 12	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261/ASTM F1055/ASTM D2683	40 05 33.13	
			FLG, FSW, EFSW, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D 3035/AWWA C901		
	14 thru 20	IPS SDR 11	FLG, BFW, HPEG, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
		IPS SDR 17	FLG, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906		
	22 thru 60	IPS SDR 11	FLG, BFW, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
	50 thru 72	3/8 in. Thk.	FLG, RBAS, DLW, BW	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 5
Taps	1/2 thru 3	Sch. 80	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	
		IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
	Ductile Iron, All	Sch. 40	THD	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 19	7
	HDPE, 4 thru 60	IPS SDR 11	BFW, FSW	Fabricated Reducing Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
		IPS SDR 17	EFSW, FSW	Electrofusion Branch Saddle Tap: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F1055, with reducers and HDPE to 316 Stainless Steel MNPT transition		
Taps (continued)	Steel, All	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Grooved Coupling	4 thru 36	M or E Pipe	CGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	40 05 19	
	8 thru 36	M or E Pipe	HGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per manufacturer's standard	40 05 33.13	
	2 thru 20	M or E Pipe	HPEG	Flexible Coupling: ASTM A536 Gr 65/45/12, Gripping Teeth per manufacturer's standard	40 05 33.13	
Flanges	1/2 thru 3	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
	Ductile Iron, All	250 psig	FLG	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	40 05 19	6
	HDPE, All	Class 150 IPS SDR 17	BFW x FLG	Ductile Iron Backing Ring: ASTM A536, Polypropylene coated, LJ, Dim. per ANSI B16.5 with stub end flange adapter Stub End Flange Adapters: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261	40 05 33.13	
	Steel, All	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 9 1 1 1
Flange gaskets	1/2 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	4 thru 72	—	CGRV	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gasket	4 thru 54	—	RMJ, RPO, RBAS	Neoprene or Nitrile	40 05 01	
Valves	1/2 thru 3	—	THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	12
	4 thru 60	—	FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	6, 11, 12
Insulation	All	—	—	None	—	

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Pumped Drainage	Raw Sewage	Septage.	Tank Drain	
Process Service Identifier	PD	RS	SEP	TD	

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Encasement for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. No lining or coating for HDPE Pipe.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. BW (Butt Weld) and RJC (Ring Joint Coupling) connections/joints not permitted for 14-inch through 24 inch pipe.
11. Install plug valve with seat at the inlet or upstream connection to piping.
12. Provide square nut operator, extension stem, and valve box for buried valves.
13. PGRV (Proprietary Groove): Victaulic Advanced Groove System or Approved Equal
14. RJC (Ring Joint Coupling): Victaulic Vic-Ring Coupling or Approved Equal with welded pipe shoulders or ring adapters
15. Where specified pipe wall thickness (Rating) is insufficient for cut grooves, provide shouldered ends, ring adapters, or increase pipe wall thickness as necessary for installation of cut grooves.
16. Provide rigid couplings except for pipe installed on pipe racks in pipe/utility tunnels or chases.
17. HPEG (HDPE Plain End with Gripping Teeth): Victaulic Style 995N, Victaulic Style 905, or Approved Equal.

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

18. HGRV (HDPE Groove Coupling): Victaulic Style 908 or Approved Equal.
19. Provide Fiberglass or Mineral Wool Insulation for Energy Conservation on CS lines installed in Indoor Dry and Indoor Wet exposures. Insulation for Energy Conservation is not required for other Process Services specified in this Piping System Schedule.

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 3	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	4 thru 12	Sch. 40 or STD	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
	14 thru 24	Sch. 20	CGRV, RGRV, PGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	13
		1/4 in. Thk.	CGRV, RGRV, PGRV, FLG,	Steel: AWWA C200		13, 15
	26 thru 48	5/16 in. Thk.	PGRV	Steel: AWWA C200	40 05 24	13
		1/4 in. Thk.	BW, FLG, RJC	Steel: AWWA C200		14
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG, PGRV, RJC	Steel: AWWA C200	40 05 24	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 72	Thk. per Std.	—		40 05 24	
			—			
			—	Ceramic Epoxy: Per Specification, Factory Applied		
			—			
External Coating	All	16 mils DFT	—		40 05 24	
		16 mils DFT	—			
		Thk. per Std.	—	Polyurethane: Factory Applied, AWWA C222		
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
Fittings	1/8 thru 2-1/2	Class 150	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3	40 05 24	
		Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
	3 thru 24	Class 150	CGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	
		M or E Pipe	CGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		
		Sch. 40 or STD	CGRV, RGRV	Wrought Steel Grooved End: ASTM A234-WPB, r/D Dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.		
		Sch. 40 or STD	CGRV, RGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

		Sch. 40 or STD	FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		
	14 thru 48	M or E Pipe	PGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	40 05 24	13
		Sch. 40 or STD	PGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3, 13
		1/4 in. Thk.	BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208		3, 10, 14
		Sch. 40 or STD	BW, FLG, RJC	Wrought Steel: ASTM A234-WPB, r/D Dim. per ASME B16.9, grooved tangents for RJC Conn./Joints		2, 10, 14
	50 thru 72	3/8 in. Thk.	PGRV, DLW, BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Taps	1/2 thru 2-1/2	Class 3000	THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
		Class 150	THD	Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 150	THD	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3		
	3 thru 72	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4
Grooved Coupling	3 thru 12	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	16
	14 thru 24	M or E Pipe	CGRV, RGRV	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 72	M or E Pipe	PGRV, RJC	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	10
Flanges	4 thru 24	Class 150	LWN, WN, SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	40 05 24	
		Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207		
	26 thru 72	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	—	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	
				Swing Check: Bronze 40 05 65.01		
	3 thru 48		FLG	Plug: AWWA C517, Standard Port, 40 05 62.01 Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16	40 05 60	11
	50 thru 72		FLG	Butterfly: AWWA C504, Class 150B, 40 05 64.05 Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16	40 05 60	
Insulation	3/8 thru 8	1 in. Thk.	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 72	1 in. Thk.	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	½ thru 36	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium-Temperature Range, Energy Conservation, Aluminum Jacket/Covers	40 42 00	19
	42 thru 60	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type III Grade A, Medium-Temperature Range, Energy Conservation, Aluminum Jacket/Covers	40 42 00	19

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 3	Sch. 80 IPS DR 17	THD, FLG, SLV FLG, FSW, EFSW, BFW, HPEG	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785 High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901	40 05 31.13 40 05 33.13	5 5, 17
	4 thru 12	Pr. Class 350	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	14 thru 54	Pr. Class 250	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	4 thru 36	Class 53	CGRV	Ductile Iron: AWWA C151	40 05 19	5
	4 thru 60	IPS DR 17	FLG, BFW, HPEG, HGRV	High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906	40 05 33.13	5, 17, 18
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Lining for Pipe & Fittings	1/2 thru 3	—	—	None	—	7
	Ductile Iron, All	40 mils	—	Ceramic Epoxy: Per Specification, Factory Applied	40 05 19	
	HDPE, All	—	—	None		8
	Steel, All	Thk. per Std. 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Cement Mortar: AWWA C205, NSF 61 certified, Factory Applied Liquid Epoxy: AWWA C210, NSF 61 certified, Factory Applied Fusion-Bonded Epoxy: AWWA C213, NSF 61 certified, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
External Coating	1/2 thru 3	—	—	None	—	
	HDPE, All	—	—	None		8
	Ductile Iron, All	Thk. per Std. Thk. per Std. — —	— — — —	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied Polyethylene Encasement: AWWA C105, Field Installed Zinc Coating with Asphaltic Top Coat: Per Specification, Factory Applied V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed	40 05 19	
External Coating (continued)	Steel, All	80 mils 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Tape Wrap: AWWA C209 and AWWA C214, Factory Applied Liquid Epoxy: AWWA C210, Factory Applied Fusion-Bonded Epoxy: AWWA C213, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
	Valves	—	—	Coating System M-1: Per specification, Field Applied	09 90 00	
Fittings	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	5

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
	4 thru 12	350 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	14 thru 36	250 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	4 thru 24	350 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	30 thru 54	250 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	1/2 thru 12	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261	40 05 33.13	
			FLG, FSW, EFSW, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D 3035/AWWA C901		
	14 thru 20	IPS SDR 11	FLG, BFW, HPEG, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
		IPS SDR 17	FLG, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906		
	22 thru 60	IPS SDR 11	FLG, BFW, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
	50 thru 72	3/8 in. Thk.	FLG, RBAS, DLW, BW	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 5
Taps	1/2 thru 3	Sch. 80	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	
		IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
	Ductile Iron, All	Sch. 40	THD	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 19	7
	HDPE, 4 thru 60	IPS SDR 11	BFW, FSW	Fabricated Reducing Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
		IPS SDR 17	EFSW, FSW	Electrofusion Branch Saddle Tap: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F1055, with reducers and HDPE to 316 Stainless Steel MNPT transition		
	Steel, All	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Solids						
Process Service Identifier	SL						

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Grooved Coupling	4 thru 36	M or E Pipe	CGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	40 05 19	
	8 thru 36	M or E Pipe	HGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per manufacturer's standard	40 05 33.13	
	2 thru 20	M or E Pipe	HPEG	Flexible Coupling: ASTM A536 Gr 65/45/12, Gripping Teeth per manufacturer's standard	40 05 33.13	
Flanges	1/2 thru 3	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
	Ductile Iron, All	250 psig	FLG	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	40 05 19	6
	HDPE, All	Class 150 IPS SDR 17	BFW x FLG	Ductile Iron Backing Ring: ASTM A536, Polypropylene coated, LJ, Dim. per ANSI B16.5 with stub end flange adapter Stub End Flange Adapters: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2280	40 05 33.13	
	Steel, All	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 9 1 1 1
Flange gaskets	1/2 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	4 thru 72	—	CGRV	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gasket	4 thru 54	—	RMJ, RPO, RBAS	Neoprene or Nitrile	40 05 01	
Valves	1/2 thru 3	—	THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	12
	4 thru 48	—	FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	6, 11, 12
	50 thru 72		FLG	Butterfly: AWWA C504, Class 150B, 40 05 64.05	40 05 60	6, 12
Insulation	All	—	—	None	—	

END OF SECTION

Schedule 40 05 02.63 – Chemical Solution

Process Service	Anionic Polymer	Cationic Polymer	Nonionic Polymer	Sodium Hypochlorite	
Process Service Identifier	PEA	PEC	PEN	SH	

Test Conditions

Pressure (psig)	Duration (min.)	Medium
70	120	Water

General Requirements

1. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, and NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.
2. For SHS (VENT) provide pipe as for SHS
3. Full-Faced flanges mated with raised face flanges are not permitted.
4. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
5. Pipe threads per ASME B1.20.1.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide square nut operator, extension stem, and valve box for buried valves.
4. Install Secondary Containment on Exposed pipe and fittings to the limits specified on the Drawings. Secondary Containment Pipe per Section 40 05 31.19.
5. Install Secondary containment on all Buried and Encased pipe and fittings. Secondary Containment Pipe per Section 40 05 31.19.
6. Coat all pipe exposed to sunlight. Omit coating for insulated pipe.
7. For HOCL service, provide clear PVC vent lines on the discharge of automatic degassing valves.
8. Ball valves are not permitted on sodium hypochlorite service.

Schedule 40 05 02.63 – Chemical Solution

Process Service	Anionic Polymer	Cationic Polymer	Nonionic Polymer	Sodium Hypochlorite	
Process Service Identifier	PEA	PEC	PEN	SH	

Indoor Dry, Indoor Wet, Outdoor, Submerged, Process Corrosive, Chemical Corrosive, Head Space – Exposed and Buried (Includes Encased and Embedded)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/4 thru 24	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	4, 5
Lining for Pipe & Fittings	All	—	—	None	—	
External Coating	All	3 mils DFT	—	Latex Acrylic: Field Coated, Coating System L-2, Coat per Specification	09 90 00	6
	Valves	3 mils DFT	—	Latex Acrylic: Field Coated, Coating System L-2, Coat per Specification	09 90 00	6
Fittings	All	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2466	40 05 31.13	4, 5
Taps	All	Sch. 40	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2466, Reducing bushings as necessary	40 05 31.13	
Grooved Coupling	All	—	—	None	—	
Flanges	2 thru 24	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
FLG Bolts, nuts and hardware	All	—	—	Stainless Steel Bolts: ASTM A320-B8M Stainless Steel Nuts: ASTM A194-8M Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 2
Flange gaskets	All	1/16 in Thk.	FLG	PTFE bonded EPDM	40 05 01	
Mechanical Coupling Gaskets	All	—	—	None	—	
Compression and Push-On Gasket	All	—	—	None	—	
Valves	1/2		THD x SLV	PVC Degassing: 40 05 72.81	40 05 60	7
	1/8 thru 4	—	SLV	PVC Ball: 40 05 63.05 PVC Diaphragm:40 05 74.05 PVC Ball Check: 40 05 65.04	40 05 60	3, 8
	2 thru 14	—	FLG	PVC Butterfly: 40 05 64.13	40 05 60	3, 8
	2 thru 8	—	FLG	PVC Swing Check: 40 05 65.25		
Insulation	3/8 thru 8	1 in. Thk.	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 60	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers		

Schedule 40 05 02.65 – Chemical Solution

Process Service	Ferric Chloride	Fluoride			
Process Service Identifier	FEC	FL			

Test Conditions

Pressure (psig)	Duration (min.)	Medium
150	120	Water

General Requirements

1. Solvent welding of CPVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.
2. For SHS (VENT) provide pipe as for SHS
3. Full-Faced flanges mated with raised face flanges are not permitted.
4. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
5. Pipe threads per ASME B1.20.1.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide square nut operator, extension stem, and valve box for buried valves.
4. Install Secondary Containment on Exposed pipe and fittings to the limits specified on the Drawings. Secondary Containment Pipe per Section 40 05 31.19.
5. Install Secondary containment on all Buried and Encased pipe and fittings. Secondary Containment Pipe per Section 40 05 31.19.
6. Coat all pipe exposed to sunlight. Omit coating for insulated pipe.
7. For HOCL service, provide clear PVC vent lines on the discharge of automatic degassing valves.
8. Ball valves are not permitted on sodium hypochlorite service.

Schedule 40 05 02.65 – Chemical Solution

Process Service	Ferric Chloride	Fluoride			
Process Service Identifier	FEC	FL			

Indoor Dry, Indoor Wet, Outdoor, Submerged, Process Corrosive, Chemical Corrosive, Head Space – Exposed and Buried (Includes Encased and Embedded)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/4 thru 24	Sch. 80	SLV	CPVC: ASTM D1784-Class 23447-B, NSF 61 certified, Dim. Per ASTM F441	40 05 31.19	4, 5
Lining for Pipe & Fittings	All	—	—	None	—	
External Coating	All	3 mils DFT	—	Latex Acrylic: Field Applied, Coating System L-2, Coat per Specification	09 90 00	6
	Valves	3 mils DFT	—	Latex Acrylic: Field Applied, Coating System L-2, Coat per Specification	09 90 00	6
Fittings	All	Sch. 80	SLV	CPVC: ASTM D1784-Class 23447-B, Dim. Per ASTM F439	40 05 31.13	4, 5
Taps		Sch. 80	SLV	CPVC Tee: ASTM D1784-Class 23447-B, Dim. Per ASTM F439, Reducing bushings as necessary	40 05 31.13	
Grooved Coupling	All	—	—	None	—	
Flanges	2 thru 24	Class 150	SLV x FLG	CPVC: ASTM A1784-Class 23447-B, FF, Dim. per ASME B16.5	40 05 31.13	
FLG Bolts, nuts and hardware	All	—	—	Stainless Steel Bolts: ASTM A320-B8M Stainless Steel Nuts: ASTM A194-8M Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 2
Flange gaskets	All	1/16 in Thk.	FLG	PTFE bonded EPDM	40 05 01	
Mechanical Coupling Gaskets	All	—	—	None	—	
Compression and Push-On Gasket	All	—	—	None	—	
Valves	1/2		THD x SLV	CPVC Degassing: 40 05 72.82	40 05 60	7
	1/4 thru 4	—	SLV	CPVC Ball: 40 05 63.06 CPVC Diaphragm: 40 05 74.06 CPVC Ball Check: 40 05 65.05	40 05 60	3, 8
	2 thru 14	—	FLG	CPVC Butterfly: 40 05 64.15	40 05 60	3, 8
	2 thru 8	—	FLG	CPVC Swing Check: 40 05 65.26		
Insulation	3/8 thru 8	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 60	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers		

Schedule 40 05 02.65 – Chemical Solution

Process Service	Ferric Chloride	Fluoride			
Process Service Identifier	FEC	FL			

Indoor – In Containment, Above Ground

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Tubing	1/2 thru 1-1/2	150 psi	CPRSN	White Polypropylene Tubing: Parker-Hannifin PP Series, or approved equal; 150 psi Min. Working Pressure at 70 deg F.	-	4, 5, 11
Secondary Containment Pipe	2 thru 6	Sch. 80	SLV	CPVC: ASTM D1784-Class 23447-B, NSF 61 certified, Dim. Per ASTM F441	40 05 31.19	4, 5
Lining for Pipe & Fittings	All	—	—	None	—	
External Coating	All	3 mils DFT	—	Latex Acrylic: Field Applied, Coating System L-2, Coat per Specification	09 90 00	6
	Valves	3 mils DFT	—	Latex Acrylic: Field Applied, Coating System L-2, Coat per Specification	09 90 00	6
Fittings	All	Sch. 80	SLV	CPVC: ASTM D1784-Class 23447-B, Dim. Per ASTM F439	40 05 31.13	4, 5
Taps		Sch. 80	SLV	CPVC Tee: ASTM D1784-Class 23447-B, Dim. Per ASTM F439, Reducing bushings as necessary	40 05 31.13	
Grooved Coupling	All	—	—	None	—	
Flanges	2 thru 24	Class 150	SLV x FLG	CPVC: ASTM A1784-Class 23447-B, FF, Dim. per ASME B16.5	40 05 31.13	
FLG Bolts, nuts and hardware	All	—	—	Stainless Steel Bolts: ASTM A320-B8M Stainless Steel Nuts: ASTM A194-8M Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 2
Flange gaskets	All	1/16 in Thk.	FLG	PTFE bonded EPDM	40 05 01	
Mechanical Coupling Gaskets	All	—	—	None	—	
Compression and Push-On Gasket	All	—	—	None	—	
Valves	1/2		THD x SLV	CPVC Degassing: 40 05 72.82	40 05 60	7
	1/4 thru 4	—	SLV	CPVC Ball: 40 05 63.06 CPVC Diaphragm: 40 05 74.06 CPVC Ball Check: 40 05 65.05	40 05 60	3, 8
	2 thru 14	—	FLG	CPVC Butterfly: 40 05 64.15	40 05 60	3, 8
	2 thru 8	—	FLG	CPVC Swing Check: 40 05 65.26		
Insulation	3/8 thru 8	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 60	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers		

Schedule 40 05 02.65 – Chemical Solution

Process Service	Ferric Chloride	Fluoride			
Process Service Identifier	FEC	FL			

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Section 40 05 02. 66

Piping System Schedule, Chemical Solution, Stainless Steel Pipe

Process Service	Flash Mix							
Process Service Identifier	***FMX***							

General Requirements

A. Testing Requirements: Pressure: 150 psig. Duration: 120 min. Medium: Water

B. Comply with the provisions of Section 40 05 01 in addition to the requirements specified herein. Refer to Section 40 05 02 for definitions of abbreviations and acronyms used in this schedule.

C. Design, fabricate, inspect, and test in accordance with the ASME B31.3 Process Piping Code.

D. ASME B31.3 Design Requirements: Pressure: 100 psig. Temperature: 120 F Fluid Service Category: Normal

E. Full-Faced flanges mated with raised face flanges are not permitted.

F. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

G. Pipe threads per ASME B1.20.1.

H. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel. Weld Type 316L to Type 316L pipe material.)

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
4. Provide stainless steel flange bolts, nuts, and washers with stainless steel flanges.

Area Exposure Types: Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec. Section	Key Notes
Pipe	1/2 thru 3	Stainless Steel: ASTM A312-TP316L, SML, Dim. Per ASME B36.19.	Sch. 40S	BW, SW, THD, FLG	40 05 23	
Lining for Pipe & Fittings	All	None	—	—	—	
External Coating	All	None	—	—	—	
	Valves	None	—	—	—	
Fittings	1/2 thru 3	Forged Stainless Steel: ASTM A182-F316L, Dim. per ASME B16.11.	Class 3000	SW, THD	40 05 23	3
		Wrought Stainless Steel: ASTM A403-WP316L, Dim. per ASME B16.9.	Sch. 40S	BW, FLG	40 05 23	3
		Cast Stainless Steel: ASTM A351-CF8M, Dim. per ASME B16.3	Class 150	THD	40 05 23	3
Taps	1/2 thru 3	Forged Stainless Steel Tee: ASTM A182-F316L, Dim. per ASME B16.11	Class 3000	THD, SW	40 05 23	
		Wrought Stainless Steel Tee: ASTM A403-WP316L, Dim. per ASME B16.9.	Sch. 40S	BW	—	
		Cast Stainless Steel Tee: ASTM A351-CF8M, Dim. per ASME B16.3	Class 150	THD	40 05 23	
Grooved Coupling	All	None	—	—	—	
Flanges	1/2 thru 3	Forged Stainless Steel: ASTM A182-F316L, FF, Dim. per ASME B16.5.	Class 150	WN, SO, THD	40 05 23	4
FLG Bolts, nuts and hardware	All	Stainless Steel Bolts: ASTM A193 Gr B8M Stainless Steel Nuts: ASTM A194 Gr 8M	—	—	—	1, 2, 4
Flange gaskets	1/2 thru 3	Viton/FKM	1/16 in	FLG	40 05 01	
Mechanical Coupling Gaskets	All	None	—	—	—	
Compression and Push-On Gaskets	All	None	—	—	—	
Valves	1/2 thru 3	Ball: 316 Stainless Steel Body/Ball, 40 05 63.23 Check: Swing Check, Stainless Steel, 40 05 65.20	—	THD THD, FLG	40 05 60	
Insulation	1/2 thru 3	None	—	—	—	

END OF SECTION

Schedule 40 05 02.89 – Building Mechanical Drainage

Piping Service	Drain	Roof Drain Leader	Sanitary Sewer		
Piping Service Abbreviation	DR	RDL	SS		

Test Conditions

Pressure (psig)	Duration (min.)	Medium
5.0	15	Water

General Requirements

1. Minimum test conditions specified above. Comply with applicable local plumbing code.
2. Sleeve drain, waste and vent piping through structural concrete and masonry.
3. Piping under structures, concrete encased pipe from the structure, and piping extended from the structure through the interface between piped commodities common to process/mechanical and yard piping, shall be either CISP or DIP, as specified.
4. Provide a union or flanged connection within 2 ft of any threaded valve and within 3 ft of any wall penetration.
5. Refer to Section 22 40 00 for plumbing fixtures and trim.
6. Provide copper tube for Outdoor HVAC equipment condensate drains.
7. Pipe Threads per ASME B1.20.1.

Notes:

1. Provide cast iron soil pipe for buried pipe within 5 feet of building perimeter. Pipe materials transition to be at least 6 in above slab or 6 inches inside building perimeter wall.
2. Provide long radius elbows.
3. Provide magnetic tracer tape,
4. Provide BAS joints with embedded steel joint rings for 30-inch and larger RCP.
5. Pipe Tape Wrap is not required for pipe installed in Indoor Dry, Indoor Wet, and Outdoor Area Exposures.
6. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
7. Provide Non Corrosive, High-Strength, Low-Alloy Steel Bolts or fluoropolymer coated Carbon Steel Bolts for flanges installed in Buried Area Exposure.
8. PVC lining is not required for D, RWP, and STD service.
9. Fabricated (miter cut pipe) PVC fittings are not acceptable.
10. Unreinforced Precast Concrete Manholes: 6 inch minimum wall thickness. Reinforced Precast Concrete Manholes: 4 inch minimum wall thickness. Provide Rubber gasket joints or mastic sealant joints between Precast Concrete Manhole Sections.
11. Bolts and nuts with metallurgy specified in AWWA C111.
12. Install per Cast Iron Soil Pipe Institute recommended practice specified in Cast Iron Soil Pipe and Fittings Handbook.
13. Provide Polyethylene Encasement: per AWWA C105, Field Applied, for Buried pipe under buildings and within 5 feet of building perimeter.

Schedule 40 05 02.89 – Building Mechanical Drainage

Piping Service	Drain	Roof Drain Leader	Sanitary Sewer		
Piping Service Abbreviation	DR	RDL	SS		

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, and Headspace – Exposed and Buried (Includes Embedded and Encased) Under Buildings and Within 5 feet of Building Perimeter

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/4 thru 1-1/2	Type M	SLDR	Copper Tube: ASTM B88, Drawn	40 05 17	
	1-1/4 thru 12	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B or ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.17	3
	2 thru 12	SV	HAS, HBLS	Cast Iron (CISP): ASTM A74 or ASTM A888	—	1, 12
	14 thru 48	Thk. Class 53	FLG, CGRV	Ductile iron: AWWA C151, Dim. Per AWWA C150	40 05 19	
Lining for Pipe & Fittings	1/4 thru 1-1/2	—	—	None:	—	
	PVC, All	—	—	None:	—	
	Cast Iron, All	—	—	Asphaltic: Manufacturer's Standard, Factory Applied	—	
	Ductile Iron, > 3 in	—	—	Cement-mortar: AWWA C104 w/asphaltic seal coat, NSF 61 certified, Factory Applied	40 05 19	
External Coating	1/4 thru 1-1/2	2 wraps / layers	—	Pipe Wrap Tape: Polyethylene or PVC tape, Field Applied on Installed Pipe	—	5
	PVC, All	—	—	None:	—	
	Cast Iron, All	—	—	Asphaltic: Manufacturer's Standard, Factory Applied	—	13
	Ductile Iron, All	Thk. per Std.	—	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied	40 05 19	13
	Valves	—	—	None:	—	
Fittings	1/4 thru 1-1/2	Class 150	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3	40 05 24	2
		Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
		—	SLDR	Wrought Copper and Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.22	40 05 17	
		—	SLDR	Cast Copper Alloy (Brass or Bronze): Materials and Dim. per ASME B16.18		
Fittings (continued)	PVC, All	Sch. 40	SLV	PVC: ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D3311	40 05 31.17	2
	Cast Iron, All	SV	HAS, HBLS	Cast Iron (CISP): ASTM A74 or ASTM A888	—	2, 5, 12
	14 thru 48	250 psi	FLG, CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	2
Taps	All	—	—	None:		
Grooved Coupling	14 thru 36	M or E Pipe	CGRV	Flexible grooved coupling: ASTM A536-65/12, Dim. Per AWWA C606	40 05 19	

Schedule 40 05 02.89 – Building Mechanical Drainage

Piping Service	Drain	Roof Drain Leader	Sanitary Sewer		
Piping Service Abbreviation	DR	RDL	SS		

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, and Headspace – Exposed and Buried (Includes Embedded and Encased) Under Buildings and Within 5 feet of Building Perimeter

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Flanges	14 thru 48	250 psi	FLG	Ductile iron: AWWA C115 for pipe or AWWA C110 for fittings	40 05 19	
FLG Bolts, nuts, and hardware	All	—	—	Carbon Steel Bolts: ASTM A307-Gr A with Carbon Steel Nuts: ASTM A563-Gr A, 1/4" thru 1-1/2" use Gr A hex nuts, 1-5/8" thru 3" use Gr A heavy hex nuts	—	6, 7
		—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D	—	6, 7, 11
		—	—	Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal		6, 7
Flange gaskets	14 thru 48	1/8 in Thk.	FLG	Neoprene	40 05 01	
Mechanical Coupling Gaskets	14 thru 48	—	CGRV	Neoprene or Nitrile	40 05 01	
Compression and Push-On Gasket	2 thru 12	—	HAS, HBLS	Neoprene or Nitrile	40 05 01	
Valves	All	—	—	None	—	
Insulation	½ thru 36	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium-Temperature Range, Condensation Control, Aluminum Jacket/Covers		

Schedule 40 05 02.89 – Building Mechanical Drainage

Piping Service	Drain	Roof Drain Leader	Sanitary Sewer		
Piping Service Abbreviation	DR	RDL	SS		

Buried (Includes Encased and Embedded) 5 feet Beyond Building Perimeter - Yard Piping

See Civil Yard Piping Plans For Materials and Specification Reference

END OF SECTION

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Surround for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. No lining or coating for HDPE Pipe.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. BW (Butt Weld) and RJC (Ring Joint Coupling) connections/joints not permitted for 14-inch through 24 inch pipe.
11. Install plug valve with seat at the inlet or upstream connection to piping.
12. Provide square nut operator, extension stem, and valve box for buried valves.
13. PGRV (Proprietary Groove): Victaulic Advanced Groove System or Approved Equal
14. RJC (Ring Joint Coupling): Victaulic Vic-Ring Coupling or Approved Equal with welded pipe shoulders or ring adapters
15. Where specified pipe wall thickness (Rating) is insufficient for cut grooves, provide shouldered ends, ring adapters, or increase pipe wall thickness as necessary for installation of cut grooves.
16. Provide rigid couplings except for pipe installed on pipe racks in below pipe/utility tunnels or chases.
17. HPEG (HDPE Plain End with Gripping Teeth): Victaulic Style 995N, Victaulic Style 905, or Approved Equal.

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

18. HGRV (HDPE Groove Coupling): Victaulic Style 908 or Approved Equal.

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	3 thru 12	Sch. 40 or STD	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
	14 thru 24	Sch. 20	CGRV, RGRV, PGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	13
		1/4 in. Thk.	CGRV, RGRV, PGRV, FLG,	Steel: AWWA C200		13, 15
	26 thru 48	5/16 in. Thk.	PGRV	Steel: AWWA C200	40 05 24	13
		1/4 in. Thk.	BW, FLG, RJC	Steel: AWWA C200		14
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG, PGRV, RJC	Steel: AWWA C200	40 05 24	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 72	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210, NSF 61 certified	40 05 24	
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
Fittings	1/8 thru 2-1/2	Class 150	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3	40 05 24	
		Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
Fittings (continued)	3 thru 24	Class 150	CGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	
		M or E Pipe	CGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		
		Sch. 40 or STD	CGRV, RGRV	Wrought Steel Grooved End: ASTM A234-WPB, r/D Dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.		

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
		Sch. 40 or STD	CGRV, RGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3
		Sch. 40 or STD	FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		
	14 thru 48	M or E Pipe	PGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	40 05 24	13
		Sch. 40 or STD	PGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		3, 13
		1/4 in. Thk.	BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208		3, 10, 14
		Sch. 40 or STD	BW, FLG, RJC	Wrought Steel: ASTM A234-WPB, r/D Dim. per ASME B16.9, grooved tangents for RJC Conn./Joints		2, 10, 14
	50 thru 72	3/8 in. Thk.	PGRV, DLW, BW, FLG, RJC	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Taps	1/2 thru 2-1/2	Class 3000	THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
		Class 150	THD	Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 150	THD	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3		
	3 thru 72	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4
Grooved Coupling	3 thru 12	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	16
	14 thru 24	M or E Pipe	CGRV, RGRV	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 72	M or E Pipe	PGRV, RJC	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	10
Flanges	4 thru 24	Class 150	LWN, WN, SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	40 05 24	
		Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207		
	26 thru 72	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	—	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	
				Swing Check: Bronze 40 05 65.01		
	3 thru 60		FLG	Plug: AWWA C517, Standard Port, 40 05 62.01 Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16	40 05 60	11
Insulation	3/8 thru 8	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 72	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 3	Sch. 80 IPS DR 17	SLV FSW, EFSW, BFW, HPEG	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785 High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901	40 05 31.13 40 05 33.13	5 5, 17
	4 thru 12	Pr. Class 350	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	14 thru 54	Pr. Class 250	RMJ, RPO, FLG	Ductile Iron: AWWA C151	40 05 19	5, 6
	4 thru 36	Class 53	CGRV	Ductile Iron: AWWA C151	40 05 19	5
	4 thru 60	IPS DR 17	FLG, BFW, HPEG, HGRV	High Density Polyethylene: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906	40 05 33.13	5, 17, 18
	50 thru 72	3/8 in. Thk.	DLW, BW, FLG	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 13
Lining for Pipe & Fittings	1/2 thru 3	—	—	None	—	7
	Ductile Iron, All	40 mils	—	Ceramic Epoxy: Per Specification, Factory Applied Cement Mortar: AWWA C104, NSF 61 certified, Factory Applied	40 05 19	
	HDPE, All	—	—	None		8
	Steel, All	Thk. per Std. 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Cement Mortar: AWWA C205, NSF 61 certified, Factory Applied Liquid Epoxy: AWWA C210, NSF 61 certified, Factory Applied Fusion-Bonded Epoxy: AWWA C213, NSF 61 certified, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
External Coating	1/2 thru 3	—	—	None	—	
	HDPE, All	—	—	None		8
	Ductile Iron, All	Thk. per Std. Thk. per Std. — —	— — — —	Asphaltic: Manufacturer's Standard, AWWA C151, Factory Applied Polyethylene Encasement: AWWA C105, Field Installed Zinc Coating with Asphaltic Top Coat: Per Specification, Factory Applied V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed	40 05 19	
	Steel, All	80 mils 16 mils DFT 12 mils CFT Thk. per Std.	— — — —	Tape Wrap: AWWA C209 and AWWA C214, Factory Applied Liquid Epoxy: AWWA C210, Factory Applied Fusion-Bonded Epoxy: AWWA C213, Factory Applied Polyurethane: AWWA C222, Factory Applied	40 05 24	
	Valves	—	—	Coating System M-1: Per specification, Field Applied	09 90 00	
Fittings	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	5

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
	4 thru 12	350 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	14 thru 36	250 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	5
	4 thru 24	350 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	30 thru 54	250 psi	RMJ, FLG, RPO	Ductile Iron: AWWA C110 or AWWA C153	40 05 19	5, 6
	1/2 thru 12	IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261/ASTM F1055/ASTM D2683	40 05 33.13	
			FLG, FSW, EFSW, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D 3035/AWWA C901		
	14 thru 20	IPS SDR 11	FLG, BFW, HPEG, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
		IPS SDR 17	FLG, BFW, HPEG, HGRV	Long Radius Sweep Bend: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F714/AWWA C906		
	22 thru 60	IPS SDR 11	FLG, BFW, HGRV	Fabricated Fittings: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F2206	40 05 33.13	
	50 thru 72	3/8 in. Thk.	FLG, RBAS, DLW, BW	Fabricated Steel: AWWA C200, Dim. per AWWA C208	40 05 24	3, 5
Taps	1/2 thru 3	Sch. 80	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	
		IPS SDR 17	FLG, FSW, EFSW, BFW, HPEG, HGRV	Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
	Ductile Iron, All	Sch. 40	THD	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 19	7
	HDPE, 4 thru 60	IPS SDR 11	BFW, FSW	Fabricated Reducing Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3035/AWWA C901, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 33.13	
		IPS SDR 17	EFSW, FSW	Electrofusion Branch Saddle Tap: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM F1055, with reducers and HDPE to 316 Stainless Steel MNPT transition		
Taps (continued)	Steel, All	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4

Schedule 40 05 02.AA – Process Drains

Process Service	Backwash / Waste Backwash	Filter to Waste / Overflow	Process Drain / Sump Pump Discharge	Decant Water	
Process Service Identifier	BW / WBW	FTW / OF	PD / SPD	DW	

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Grooved Coupling	4 thru 36	M or E Pipe	CGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per AWWA C606	40 05 19	
	8 thru 36	M or E Pipe	HGRV	Flexible Coupling: ASTM A536 Gr 65/45/12, Groove Dim. per manufacturer's standard	40 05 33.13	
	2 thru 20	M or E Pipe	HPEG	Flexible Coupling: ASTM A536 Gr 65/45/12, Gripping Teeth per manufacturer's standard	40 05 33.13	
Flanges	1/2 thru 3	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
	Ductile Iron, All	250 psig	FLG	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	40 05 19	6
	HDPE, All	Class 150 IPS SDR 17	BFW x FLG	Ductile Iron Backing Ring: ASTM A536, Polypropylene coated, LJ, Dim. per ANSI B16.5 with stub end flange adapter Stub End Flange Adapters: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261	40 05 33.13	
	Steel, All	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 9 1 1 1
Flange gaskets	1/2 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	4 thru 72	—	CGRV	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gasket	4 thru 54	—	RMJ, RPO, RBAS	Neoprene or Nitrile	40 05 01	
Valves	1/2 thru 3	—	THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	12
	4 thru 60	—	FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	6, 11, 12
Insulation	All	—	—	None	—	

Buried and 5 feet Beyond Building Perimeter - Yard Piping

See Civil Yard Piping Plans For Materials and Specification Reference

END OF SECTION

Schedule 40 05 02.BB – Gravity Chemical Drainage

Piping Service	Chemical Drain				
Piping Service Abbreviation	CD				

Test Conditions

Pressure (psig)	Duration (min.)	Medium
5.0	15	Water

General Requirements

1. Minimum test conditions specified above. Comply with applicable local plumbing code.
2. Sleeve drain, waste and vent piping through structural concrete and masonry.
3. Piping under structures, concrete encased pipe from the structure, and piping extended from the structure through the interface between piped commodities common to process/mechanical and yard piping, shall be either CISP or DIP, as specified.
4. Provide a union or flanged connection within 3 ft of any wall/slab penetration.
5. Refer to Section 22 40 00 for plumbing fixtures and trim.
6. Provide copper tube for Outdoor HVAC equipment condensate drains.
7. Pipe Threads per ASME B1.20.1.

Notes:

1. Provide high silicon cast iron soil pipe as shown on the drawings. Pipe materials transition to be at least 6 in above slab or 6 inches inside building perimeter wall.
2. Provide long radius elbows.
3. Provide magnetic tracer tape.
4. Provide DWV pattern fittings.
5. Pipe Tape Wrap is not required for pipe installed in Indoor Dry, Indoor Wet, and Outdoor Area Exposures.
6. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
7. Provide fluoropolymer coated Carbon Steel Bolts for flanges installed in Buried Area Exposure.
8. Fabricated (miter cut pipe) PVC fittings are not acceptable.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. Install per Cast Iron Soil Pipe Institute recommended practice specified in Cast Iron Soil Pipe and Fittings Handbook.

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, and Headspace – Exposed and Buried (Includes Embedded and Encased) Under Buildings and Within 5 feet of Building Perimeter

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1-1/4 thru 12	Sch. 40	SLV	CPVC: ASTM D1784-Class 23447, NSF 61 certified, Dim. Per ASTM D1784	40 05 31.17	
	2 thru 12	SV	HBLS	Cast Iron (CISP): ASTM A861, A518 – Grade 1	—	1, 10
	½ thru 12"	Sch 40.	HBLS, MJ	Polypropylene (PP): ASTM D4101, F1412 – PP0348		
Lining for Pipe & Fittings	1/4 thru 1-1/2	—	—	None:	—	
External Coating	1/4 thru 1-12	—	—			
	All	—	—	None:	—	
	Valves	—	—	None:	—	
Fittings	1/4 thru 1-1/2					
	PVC, All	Sch. 40	SLV	PVC: ASTM F2618, F441 - 23447	40 05 31.17	2, 3, 4
	Cast Iron, All	SV	HAS, HBLS	Cast Iron (CISP): ASTM A74 or ASTM A888	—	2, 5, 12
	PP, All	Sch. 40	BFW, FSW	Polypropylene (PP): F1412 – PP0348	—	2, 3, 4
Taps	All	—	—	None:		
Bolts, nuts, and hardware	All	—	—	Stainless Steel: CISPI 310, Series 300 SS	—	6, 7
Compression and Push-On Gasket	2 thru 12	—	HBLS, MJ	Fluoroelastomer (FKM)	40 05 01	
Valves	All	—	—	None	—	
Insulation	½ thru 12	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium-Temperature Range, Condensation Control, Aluminum Jacket/Covers		

Buried (Includes Encased and Embedded) 5 feet Beyond Building Perimeter - Yard Piping						
Component	**Line Size, in**	**Rating**	**Conn./Joints**	**Material**	**Spec Section**	**Notes**
Pipe	2 thru 12	Sch. 40	SLV	CPVC: ASTM D1784-Class 23447, NSF 61 certified, Dim. Per ASTM D1784	40 05 31.17	
	2 thru 12	SV	HBLS	Cast Iron (CISP): ASTM A861, A518 – Grade 1	—	1, 10
	2 thru 12"	Sch 40.	HAS, MJ	Polypropylene (PP): ASTM D4101, F1412 – PP0348	—	
Lining for Pipe & Fittings	2 thru 1-1/2	—	—	None:	—	
External Coating	2 thru 1-12	—	—			
	All	—	—	None:	—	
	Valves	—	—	None:	—	
Fittings	2 thru 1-1/2					
	PVC, All	Sch. 40	SLV	PVC: ASTM F2618, F441 - 23447	40 05 31.17	2, 3, 4
	Cast Iron, All	SV	HAS, HBLS	Cast Iron (CISP): ASTM A74 or ASTM A888	—	2, 5, 12
	PP, All	Sch. 40	BFW, FSW	Polypropylene (PP): F1412 – PP0348	—	2, 3, 4
Taps	All	—	—	None:		
Bolts, nuts, and hardware	All	—	—	Stainless Steel: CISPI 310, Series 300 SS	—	6, 7
Compression and Push-On Gasket	2 thru 12	—	HAS, MJ	Fluoroelastomer (FKM)	40 05 01	
Valves	All	—	—	None	—	
Insulation	2 thru 12		—	None		

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Schedule 40 05 02.89 – Structural Drainage

Piping Service	Storm Drain	Structure Underdrain	Structure Underdrain Collector		
Piping Service Abbreviation	SD	SU	SUC		

Test Conditions

Pressure (psig)	Duration (min.)	Medium
5.0	15	Water

General Requirements

1. Minimum test conditions specified above. Comply with applicable local plumbing code.
2. Provide a joint within 3 ft of any wall penetration.

Notes:

1. Provide magnetic tracer tape,
2. Fabricated (miter cut pipe) PVC fittings are not acceptable.

Schedule 40 05 02.89 – Structural Drainage

Piping Service	Storm Drain	Structure Underdrain	Structure Underdrain Collector		
Piping Service Abbreviation	SD	SU	SUC		

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, and Headspace – Exposed and Buried (Includes Embedded and Encased) Under Buildings and Within 5 feet of Building Perimeter

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	3 thru 24		B&S	HDPE (Single Wall): AASHTO M252, ASTM D3350 – Type 323410C or 333410C		
	4 thru 10	Type S	B&S	HDPE (Dual Wall): AASHTO M252, ASTM D3350 – Type S424420C or 435400C	40 05 DD	
	12 thru 60	Type S	B&S	HDPE (Dual Wall): AASHTO M294, D3350 – Type S424420C or 435400C	40 05 DD	
	4 thru 36	46 psi	B&S	PVC (Dual Wall): ASTM F949, D1784 - 12545	40 05 DD	
Lining for Pipe & Fittings	All	—	—	None:	—	
External Coating / Finishing	All		—	Perforation: Provide perforated pipe to the extents shown on the drawings Underdrain Filter: Where perforated per ASTM D6707 – Knitted Polyester	40 05 DD	5
	Valves	—	—	None:	—	
Fittings	4 thru 10	Type S	B&S	HDPE (Corrugated): AASHTO M252, ASTM D3350 – Type S424420C or 435400C		2
	12 thru 60	Type S	B&S	HDPE (Corrugated): ASTM F2306, D3350 – Type S424420C or 435400C	40 05 DD	
	4 thru 36	46 psi	B&S	PVC (Corrugated): ASTM F949 – D1784 - 12545		
Taps	All	—	—	None:	—	
Compression and Push-On Gasket	3 thru 60	Water Tight	B&S	HDPE: Per AASHTO and ASTM D1056, F477 – Grade 2A2	40 05 DD	
	4 thru 36	Water Tight	B&S	PVC: Per ASTM 3212, F477	40 05 DD	
Valves	All	—	—	None	—	
Insulation	All	.	—	None	—	

Schedule 40 05 02.89 – Structural Drainage

Piping Service	Storm Drain	Structure Underdrain	Structure Underdrain Collector		
Piping Service Abbreviation	SD	SU	SUC		

Buried (Includes Encased and Embedded) 5 feet Beyond Building Perimeter - Yard Piping

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	3 thru 24		B&S	HDPE (Single Wall): AASHTO M252, ASTM D3350 – Type 323410C or 333410C	40 05 DD	
	4 thru 10	Type S	B&S	HDPE (Dual Wall): AASHTO M252, ASTM D3350 – Type S424420C or 435400C		
	12 thru 60	Type S	B&S	HDPE (Dual Wall): AASHTO M294, D3350 – Type S424420C or 435400C	40 05 DD	
	4 thru 36	46 psi	B&S	PVC (Dual Wall): ASTM F949, D1784 - 12545	40 05 DD	
					–	
Lining for Pipe & Fittings	All	–	–	None:	–	
External Coating / Finishing	All		–	Perforation: Provide perforated pipe to the extents shown on the drawings Underdrain Filter: Where perforated per ASTM D6707 – Knitted Polyester	40 05 DD	5
	Valves	–	–	None:	–	
Fittings	4 thru 10	Type S	B&S	HDPE (Corrugated): AASHTO M252, ASTM D3350 – Type S424420C or 435400C	40 05 DD	2
	12 thru 60	Type S	B&S	HDPE (Corrugated): ASTM F2306, D3350 – Type S424420C or 435400C		
	4 thru 36	46 psi	B&S	PVC (Corrugated): ASTM F949 – D1784 - 12545		
Taps	All	–	–	None:	–	
Compression and Push-On Gasket	3 thru 60	Water Tight	B&S	HDPE: Per AASHTO and ASTM D1056 – Grade 2A2	40 05 DD	
	4 thru 36	Water Tight	B&S	PVC: Per ASTM 3212	40 05 DD	
Valves	All	–	–	None	–	
Insulation	All	.	–	None	–	

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SECTION 40 05 06.13

JOINT GASKETS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies rubber gaskets for push-on compression type joints used with fabricated steel pipe, steel pipe, reinforced concrete pipe, concrete cylinder pipe, and cement mortar lined and coated steel pipe.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D395	Rubber Property--Compression Set, Test for
ASTM D412	Rubber Properties in Tension, Test for
ASTM D471	Rubber Property--Effect of Liquids, Test for
ASTM D573	Rubber--Deterioration in an Air Oven, Test for
ASTM D1149	Rubber Deterioration--Surface Ozone Cracking in a Chamber (Flat Specimens), Test for
ASTM D2240	Rubber Property--Durometer Hardness, Test for

B. Testing:

1. Certified copies of test reports indicating that the gasket material has been tested and that the results of the tests comply with the requirements specified in paragraph 2.02 shall be provided as product data.

PART 2 PRODUCTS

2.01 MATERIALS

A. Gasket stock shall be a synthetic rubber compound in which the elastomer is neoprene. The compound shall contain no less than 50 percent by volume neoprene and shall be free from factice, reclaimed rubber and other deleterious substances.

2.02 PHYSICAL REQUIREMENTS

A. The compound shall meet the following physical requirements when tested in accordance with the specified ASTM standards.

B. Tensile (ASTM D412):
   1. The tensile strength shall be 1500 psi minimum and the ultimate elongation shall be 350 percent minimum.

C. Hardness (ASTM D2240, TYPE A DUROMETER):
   1. The compound shall have a hardness in the range of 35 to 50 for concrete spigots and 50 to 65 for steel spigots.

D. Compression Set (ASTM D395):
   1. The compression set shall not exceed 20 percent when compressed for 22 hours at 70 degrees C.
   2. The test specimens shall be circular discs cut from the gaskets. Test specimens shall be 0.500 ($\pm$ 0.005 - 0.025) inches in height. The diameter of the test specimen shall be that of the gasket but not to exceed 1.129 $\pm$ 0.010 inches in diameter.

E. Aging (ASTM D573):
   1. The test specimen deterioration shall be less than 20 percent reduction in tensile strength, 40 percent reduction in ultimate elongation, and 15 points increase in hardness.

F. Effect Of Liquids (ASTM D471):
   1. The maximum volume change in oil and in water shall be as follows:
      a. Oil: 100 percent in ASTM oil No. 3.
      b. Water: 15 percent.
   2. The test specimens shall have a thickness of 0.080 $\pm$0.005 inches and shall be circular discs cut from the gasket.

G. Ozone Cracking (ASTM D1149):
   1. The test specimen shall be a gasket loop mounted to give at least 20 percent elongation. There shall be no cracking visible at two times magnification of the gasket after 100 hours exposure to 1 mg/l ozone at 40 degrees C.

2.03 PRODUCT DATA

A. In accordance with Section 01 33 00, the Contractor shall provide certified copies of test reports specified in paragraph 1.02 Testing.

PART 3 EXECUTION

3.01 INSTALLATION

A. The gaskets shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

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SECTION 40 05 06.16

PIPING CONNECTIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the following methods of connecting metallic piping: flanges, threading, mechanical couplings, equipment connection fittings, dielectric unions, and welding.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI Bl.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI Bl.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B18.2.1	Square and Hex Bolts and Screws Inch Series
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI B31.1	Power Piping
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications
ASTM B98	Copper-Silicon Alloy Rod, Bar and Shapes
ASTM F37	Standard Test Methods for Salability of Gasket Materials
ASTM F104	Standard Classification System for Nonmetallic Gasket Materials
ASTM F152	Standard Test Methods for Tension Testing of Nonmetallic Gasket Materials
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in.

Reference	Title
AWWA C219	Bolted, Sleeve-Type Couplings for Plain-End Pipe
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
AWWA C606	Grooved and Shouldered Joints
AWWA M11	Steel Pipe-A Guide for Design and Installation
NSF 61	Drinking Water System Components - Health Effects

1.03 SUBMITTALS

A. In addition to the material listed in the detailed specification, the following submittals shall be provided in accordance with Section 01 33 00:
   1. For Equipment Connection Fittings used in pumping applications submit thrust rod stretch calculations in accordance with paragraph 2.02 Equipment Connection Fittings. and dimensional layout data.

PART 2 PRODUCTS

2.01 FLANGE ASSEMBLIES

A. Flanges:
   1. General: Flanges shall either be flat flanges or convoluted ring flanges as specified in the following paragraphs.
   2. Flat Flanges: Cast iron flanges shall be faced in accordance with ANSI B16.1. Where companion flanges are used, the flanges on pipe shall be refaced to be flush with the companion flange face. Class 150 and Class 300 forged steel flanges shall be raised face conforming to ANSI B16.5. Lightweight slip-on flanges shall be plain face conforming to AWWA C207, Class B and ANSI B16.5. Unless otherwise specified, steel flanges shall be ANSI B16.5, Class 150 or AWWA C207, Class D. Class E AWWA flanges shall be provided where test pressure exceeds 175 psi. Plain faced flanges shall not be bolted to raised face flanges.
   3. Convoluted Ring Flanges: Convoluted ring flanges shall be ductile iron, forged steel or cast stainless steel, designed to bear on hubs welded to the pipe and shall be as manufactured by Improved Piping Products. The Construction Manager knows of no equal. The flange joints shall be rated for not less than 150 percent of the test pressures listed in Section 40 05 01 and shall conform to the requirements of ANSI B 16.5 and AWWA C207. The flange manufacturer shall be prepared to demonstrate, by certified pressure test that the flanges will meet these requirements.

B. Gaskets:
   1. Gasket material shall be as specified in paragraph 2.03.
   2. Gaskets for plain faced flanges shall be the full face type. Thickness shall be 1/16 inch for pipe 10 inches and less in diameter and 1/8 inch for pipe 12 inches and larger in diameter. Unless otherwise specified, gaskets for raised face flanges shall match the raised face and shall be 1/16 inch thick for pipe 3-1/2 inches and less in diameter and 1/8 inch thick for pipe 4 inches and larger.

C. Bolts:

1. Flange assembly bolts shall be ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts. Threads shall be ANSI Bl.1, standard coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. Bolt length shall conform to ANSI B16.5.
2. Unless otherwise specified, bolts shall be carbon steel machined bolts with hot pressed hexagon nuts. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.

2.02 MECHANICAL COUPLINGS

A. Sleeve-Type Couplings:

1. Unless otherwise specified, sleeve-type mechanical pipe couplings shall be Smith-Blair Type 411, Dresser Style 38, or equal, with the stop removed from the middle ring. Reducing couplings shall be Smith-Blair Type 415, Dresser Style 62, or equal. Sleeve-type flanged coupling adapters shall be Smith-Blair Type 913, Dresser Style 128, or equal. Insulating couplings shall be Smith-Blair Type 416, Dresser Style 39, or equal.
2. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, markingF593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04, or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
3. Gaskets shall be as specified in paragraph 2.03 and AWWA C111.

B. Plain End Couplings:

1. Plain end pipe couplings for pipe sizes 6 inches and smaller shall be Gustin-Bacon 200, Victaulic Style 99, or equal for Schedule 80 pipe and Gustin-Bacon 205, Victaulic Style 90, or equal for lighter weight pipe. Plain end couplings for pipe sizes 8 inches and larger shall be Gustin-Bacon 200, Victaulic Style 99, or equal. Unless otherwise specified, bolts and nuts shall comply with AWWA C606.
2. Gaskets shall be as specified in paragraph 2.03 and AWWA C606.

C. Grooved End Couplings:

1. Grooved end flexible-type couplings shall be Gustin-Bacon 100, Victaulic Style 77, or equal. Grooved end rigid-type couplings shall be Gustin-Bacon 120 Rigi-Grip, Victaulic Style 07 Zero-Flex, or equal. Flexible-type couplings shall be used for all piping greater than 12 inches in diameter; for pipe 12 inches in diameter and less in rack-mounted tunnel piping applications; and for grooved joints adjacent to pump or blower suction and discharge where grooved couplings are used for noise and vibration control. All other applications for piping 12 inches in diameter and less shall utilize rigid-type couplings. Grooved end flanged coupling adapters shall be either Gustin-Bacon 154, Victaulic Style 741, or equal. Snap-joint grooved end couplings shall be Gustin-Bacon 115, Victaulic Style 78, or equal. Cut grooves are not permitted on fabricated or lightwall pipe.
2. Unless otherwise specified, bolts and nuts shall comply with AWWA C606. Bolts for submerged service shall be Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
3. Gaskets shall be as specified in paragraph 2.03 and AWWA C 606.

D. Equipment Connection Fittings

1. Equipment connection fittings shall provide both lateral and angular misalignment adjustment between equipment connection flanges and the connection to field piping systems by providing individually adjustable flexible joints at each connection. In addition, equipment connection fittings shall provide full pressure thrust restraint between the field piping connection and equipment connection flanges.
2. Equipment connection fittings shall consist of two flanged coupling adapters, a plain end section of pipe and thrust restraint rods and associated fittings designed to transmit thrust without transmitting shear to the thrust restraint rods and without compromising provisions for accommodating angular and parallel misalignment. Materials and features shall conform to the requirements established in this paragraph. Standard “dismantling joints” incorporate only one flanged coupling adapter and are not acceptable substitutes. Equipment connection fittings shall be Romac ECF Series, or Baker Coupling Company, Los Angeles or equal, modified as specified to provide the required features.

3. Equipment connection fittings shall each consist of a single sleeve of plain end piping conforming to the requirements of the specified piping system of sufficient length to span the gap between the connection at the equipment and the connection at the field piping with gasketed flange adapters at each end. Thrust restraint shall be provided by means of all threaded rod spanning between flanges and male rod nuts and female washers that are rounded to provide a ball-joint type self aligning feature. All threaded restraint rod shall project through flange and mating flange coupling adapter bolt holes or through holes in restraint lug plates that extend above the flanges and are secured to the flanges with a minimum of two flange bolts. Where the all threaded rods project through flange bolt holes, ball joint type nut and washer combinations and lock washers shall be provided at each face, each end. Where restraint lug plates are employed, ball joint type nuts and washers shall be provided only on the outside faces of the plates and the nuts shall have a self locking feature that prevents nut movement due to vibration or other operational or environmental causes. Double nutting with non-locking nuts shall not be an acceptable method of providing the self locking feature. Thrust rod diameter and material shall be selected to provide sufficient freedom of movement through all bolt holes to allow unrestricted maximum adjustment of equipment connection fittings to accommodate piping misalignment without transmitting any shear to the thrust rods and also to permit full development of thrust restraint at all thrust rod tension take-ups. Design of equipment connection fittings shall conform to AWWA C219.
4. Thrust rods, restraint lug plates, nuts, washers and lock washers shall be Type 316 stainless steel, all selected to develop full rated piping system pressure thrust forces. Equipment connection fittings for pump applications shall have thrust rod number and diameter selected such that thrust rod stretch under piping system operating pressure does not exceed 2 mils. Calculations shall be submitted. Dry film molybdenum di-sulfide anti-galling compound shall be factory applied to ends of thrust rods, covering all threads subject to nut travel and tightening. Gaskets shall be as specified in paragraph 2.03. Flange gaskets shall be full face type. Follower gaskets shall be compression wedge type.
5. Sleeves shall be carbon steel or as specified for the specific piping system. Pressure rating of flange adapters shall equal or exceed the pressure rating of mating flanges. All metal portions of equipment connection fittings, with the exception of 316 stainless steel components, shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61.

E. Dismantling Joints:
1. Dismantling joints may be used as takedown couplings in accordance with paragraph 3.03. Dismantling joints shall fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment. Thrust restraint shall be provided by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts. Design of equipment connection fittings shall conform to AWWA C219. Sleeves shall be carbon steel or as specified for the specific piping system. Pressure rating of flange adapters shall equal or exceed the pressure rating of mating flanges. All metal portions of equipment connection fittings, with the exception of 316 stainless steel components, shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. Dismantling joints shall be Romac DJ-400, Smith Blair 975, or Crane-Viking Johnson Dismantling Joint.

F. Sleeve Band Couplings:

1. Sleeve band couplings shall be Victaulic Depend-O-Lock. Unless otherwise noted, couplings for liquid service shall be Model F x F Type 2 fully restrained, shouldered high deflection couplings with standard width band. Couplings shall comply with AWWA C-219. Couplings for use with air systems shall be Airmaster restrained Depend-O-Lock couplings in conformance with AWWA C-606. Sleeve band couplings are acceptable wherever sleeve type couplings are used (paragraph 2.02 Sleeve Type Coupling).

G. Flexijoint:

1. Where specified Flexijoint couplings shall be Flanged Romac Flexijoint couplings. The Flexijoint is a flexible, ductile iron joint that can accommodate expansion, contraction, rotation and bending and is rated at 350 psi working pressure. The joint can accommodate 15 to 20 degree deflection depending on size. Body shall be ductile iron, lock rings Type 410 stainless steel, and ring gasket, casing, ball and cover shall be EPDM molded watertight construction. All metal portions of Flexijoint coupling including the stainless steel lock rings shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. For buried installations, install with polyethylene baggy cover in accordance with the manufacturer's instructions.

2.03 GASKETS

A. Gaskets designated in Section 40 05 01 shall be as follows:

1. EPDM: ethylene-propylene-diene-terpolymer.
2. Neoprene: neoprene.
3. Nitrile: nitrile (Buna N).
4. Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder; ASTM F104 (F712400), 2500 psi (ASTM F152), 0.2 ML/HR LEAKAGE FUEL A (ASTM F37).
5. Compressed gasketing consisting of organic fibers (Kevlar) and SBR binder; ASTM F104 (F712400), 2500 PSI (ASTM F152), 0.1 ml/hr leakage Fuel A (ASTM F37).
6. Gylon gasketing, Garlock Style 3500, 2000 psi (ASTM F152), 0.22 ml/hr Fuel A (ASTM F37).
7. Gylon gasketing, Garlock Style 3510, 2000 psi (ASTM F152), 0.04 ml/hr Fuel A (ASTM F37).
8. Gylon gasketing, Garlock Style 3504, 2000 psi (ASTM F152), 0.12 ml/hr Fuel A (ASTM F37).
9. TFE: noncreeping tetrafluoroethylene (TFE) with insert filler.
10. PTFE bonded EPDM: PTFE bonded to EPDM in full-face gasket having concentric-convex molded rings; Garlock Stress Saver 370 or equal.

2.04 THREAD

A. Pipe thread dimensions and size limits shall conform to ANSI Bl.20.1.

2.05 DIELECTRIC UNIONS

A. Dielectric unions shall be EPCO, Capitol Manufacturing, or equal.

2.06 COATINGS

A. Unless otherwise specified, flange assemblies and mechanical type couplings for buried installation shall be field coated with System M-1 as specified in Section 09 90 00.

2.07 PRODUCT DATA

A. In accordance with Section 01 33 00, the Contractor shall provide for each welder, a welder qualification certificate indicating the welder is certified for pipe welding in accordance with ASME Boiler and Pressure Vessel, Section IX. Each welder's certificate shall be provided to the Construction Manager prior to that welder working on the job.

PART 3 EXECUTION

3.01 PIPE CUTTING, THREADING AND JOINTING

A. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B31.1.

3.02 PIPE WELDING

A. Pipe shall be welded by ASME-certified welders using shielded metal arc, gas shielded arc or submerged arc welding methods. Welds shall be made in accordance with the requirements of ANSI B31.1 for piping Systems 8, 26, and 28 specified in Section 40 05 01. Welds shall be made in accordance with the requirements of ANSI B31.3 for piping System 20 specified in Section 40 05 01.

B. Welds for piping systems not specified above shall be made in accordance with AWWA C206.

3.03 TAKEDOWN COUPLINGS

A. Takedown couplings shall be screw unions, flanged or grooved end mechanical coupling type joints and shall be provided as specified. Flanged or grooved end joints shall be employed on pipelines 2-1/2 inches in diameter and larger. Where piping passes through walls, takedown couplings shall be provided within 3 feet of the wall, unless specified otherwise.

B. A union or flanged connection shall be provided within 2 feet of each threaded end valve.

3.04 FLEXIBILITY

A. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints (or a single Flexijoint) as specified on the buried pipe within 2 feet of the structure for 2-inch through 6-inch diameter pipe; within 3 feet of the structure for 8-inch through 24-inch diameter pipe; and within one and one-half pipe diameters of the structure for larger pipe. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

3.05 DIELECTRIC CONNECTIONS

A. Where a copper pipe is connected to steel or cast iron pipe, an insulating section of rubber or plastic pipe shall be provided. The insulating section shall have a minimum length of 12 pipe diameters. Dielectric unions as specified in paragraph 2.05 may be used instead of the specified insulating sections. Where copper pipe is supported from hangers, it shall be insulated from the hangers, or copper-plated hangers shall be used.

3.06 EQUIPMENT CONNECTION FITTINGS

A. Where shown, equipment connection fittings shall be provided between field piping systems and equipment inlet and outlet connections.

END OF SECTION

SECTION 40 05 06.23

EXPANSION JOINTS AND FLEXIBLE METAL HOSE

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies piping expansion joints and flexible metal hose.

B. Provide professional engineering services for a piping system design engineer (hereinafter the "Design Professional") as specified in Section 40 05 01, this Section, and related sections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 66 00 – Product Storage and Handling Requirements
   3. Section 40 05 01 – Piping Systems
   4. Section 40 05 02 – Piping System Schedules
   5. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
   6. Section 40 05 07 – Hangers and Supports for Process Piping
   7. Section 40 05 07.13 – Seismic Restraints for Piping
   8. Section 40 05 07.16 – Expansion Control for Piping

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
EJMA STDS	Standards of Expansion Joint Manufacturers' Association, Edition No. 5

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Expansion Joint: Any device used to absorb dimensional changes and/or misalignment.
   2. Pipe Section: the portion of pipe between two anchors.
   3. Lateral Direction: Direction perpendicular to the pipe axis.
   4. Longitudinal Direction: Direction parallel to the pipe axis.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordination required with the design of piping systems, piping supports (hangers, guides, anchors, structural attachments, etc.), and expansion control and seismic restraints.
   2. Select and install expansion joints and flexible metal hose in conformance with the expansion control system designed by the Design Professional, retained under the requirements of Section 40 05 01, and the criteria specified herein. This requirement, however, shall not be construed as relieving the Contractor of responsibility for this portion of the work.
   3. Refer to Section 40 05 01 for additional coordination requirements.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with addenda updates, and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.
   3. Design and construction details of formed metal bellows type expansion joints.
   4. Percent elongation over range of design temperatures.
   5. Pressure thrust force and spring rate data for formed metal bellows expansion joints.
   6. Materials, design and construction, and temperature and pressure rating for elastomer and fabric expansion joints.
   7. Details for the installation of all expansion joints.
   8. Listing of all flexible metal hose applications.

1.07 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

PART 2 PRODUCTS

2.01 PERFORMANCE / DESIGN CRITERIA

A. General:
   1. All expansion joints and flexible hose materials shall be new, free from defects and conforming to the requirements and standards specified in this Section.
   2. Furnish expansion joints and flexible metal hose as specified in Part 4 of this specification.

3. Provide control units (tie rods or restraints) to prevent excessive axial elongation and to accept the pressure thrust in the piping system. Number and sizes of control rods or restraints shall be as determined by the manufacturer.

B. Expansion Joints:
   1. Expansion joints shall be designed in accordance with EJMA Standards for pressure, temperature and service as specified in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) without crimping of corrugations.
   2. Corrugated type expansion joints shall be suitable for a minimum of 10,000 pressure, temperature and deflection cycles (non-concurrent).
   3. Supply bellows type expansion joints suitable for a minimum of 10,000 pressure, temperature and deflection cycles (non-concurrent).

C. Flexible Metal Hose:
   1. Flexible metal hose shall be suitable for a line pressure equal to the test pressure listed in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99).
   2. Live lengths for flexible metal hose shall be based on service as specified and a design life of 1,000,000 full displacement cycles.

2.02 EXPANSION JOINTS

A. Metal Construction
   1. Formed Bellows Type
      a. Medium Temperature:
         1) Formed bellows-type expansion joints for temperatures up to 800 degrees F shall have 300 series stainless steel multi-ply bellows rated for the specified design temperature and pressure.
         2) Test pressures are specified in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99). Each expansion joint shall be factory tested at the test pressure.
         3) Ductwork expansion joints may be rated at less than 50 psig but must be rated equal to the design pressure specified and, in no case, less than 2 psig.
         4) Expansion joint design shall be determined by the amount and kind of movement specified (axial, lateral, angular). Unless otherwise specified, end connections shall be flanged.
         5) Acceptable manufacturers: Formed bellows type expansion joints shall be as manufactured by U.S. Bellows, Senior Flexonics, Inc., Hyspan Precision Products, Inc., American BOA Inc. or approved equal.
      b. High Temperature:
         1) Engine and gas turbine exhaust expansion joints for temperatures up to 1300 degrees F shall be the multi-ply bellows type designed for 15 psig. Bellows shall be constructed of 300 series stainless steel.
         2) Unless otherwise specified, end connections shall be either the fixed flange or Vanstone flange configuration. Flange material shall be carbon steel for temperatures up to 1000 degrees F and stainless steel for temperatures 1000-1300 degrees F. Vanstone materials and flow liners, where specified, shall be the same as bellows material.

3) Exhaust expansion joints shall be Flexonics DEX Series, Hyspan Series 2500, American BOA Series 025E, or equal.

2. Expansion Compensator Type
   a. Steel Expansion Compresor:
      1) Compensators shall have 2-ply stainless steel bellows and carbon steel shroud and end fittings. Compensators shall be rated for 175 psi maximum working pressure and 750 degrees F.
      2) Steel expansion compensator type expansion joints shall be Flexonics Model H Expansion Compensator, Hyspan Series 8500, Keflex 7Q, or equal.
   b. Bronze Expansion Compensator:
      1) Compensators shall have multi-ply phosphor bronze or stainless steel bellows and copper tube end fittings. Compensators shall be rated for 150 psi maximum working pressure and 400 degrees F.
      2) Bronze expansion compensator type expansion joints shall be Flexonics Model HB Expansion Compensator, Hyspan Series 8500, Keflex 7Q, American BOA Inc., or equal.

B. Elastomer and Fabric Construction
   1. General Requirements:
      a. Standard spool arch type or the precision molded spherical design type as specified.
      b. Single arch and sphere type expansion joints, unless otherwise indicated, have 150-mm face-to-face dimension for pipe up to 200 and 200-mm face-to-face dimension for pipe 250 and 300. For use with larger diameters, Contractor must obtain approval from the Owner's Representative.
      c. Cover elastomer constructed of chlorobutyl, neoprene, or EPDM.
      d. Tube elastomer constructed of chlorobutyl or EPDM for temperatures between 80 and 115 degrees C. Neoprene or Buna N liners are acceptable for temperatures up to 80 degrees C.
   2. Spool Type:
      a. Resilient arch type and standard or tapered as specified. Unless otherwise specified, all tapered connectors shall be eccentric.
      b. Constructed of multiple plies of woven fabric impregnated with elastomer and reinforced with steel rings or wire embedded in the body.
      c. Provide retaining or backup rings for standard arch type expansion joints suitable for the specified temperature and pressure. Rings shall be 10-mm-thick steel, split, either galvanized or zinc shield coated.
      d. Use filled arch type expansion joints on all piping systems carrying fluids containing solids.
      e. Acceptable manufacturers for single, multiple, or filled arch: Unisource Series 1200, Garlock Style 204, Mercer Style 500, or approved equal.
      f. Acceptable manufacturers for high pressure couplings suitable for 240 degree F operating temperatures: Unisource Series 1500, Mercer Style 510, Garlock Style 204-HP, General Style 1015, or approved equal.

3. Spherical Molded Type:
    a. Spherical molded type expansion joints shall be precision molded of multiple plys of nylon tire cord fabric and elastomer suitable for specified temperature and pressure.
    b. Spherical molded type expansion joints shall have steel or ductile iron floating flanges, and no metal parts shall come in contact with the fluid.
    c. Acceptable manufacturers for single sphere molded connectors shall be Mason Type MFNC, Mercer Type 5500, Goodall Type E-611, General Type 1010, Garlock Style 8100, or approved equal.
    d. Provide double sphere or triple sphere connectors where required to provide for the specified movement.

C. Polymer Expansion Joints
    1. Provide expansion joints for PVC or CPVC piping that are EPDM elastomer flexible double-bellows. Attach expansion joints to pipe using union-type couplings.
    2. PVC/CPVC acceptable manufacturers: Spears; Flexicraft; Approved Equal.
    3. Provide PTFE expansion joint with external stainless steel reinforcing rings, limit rods, and flanges. Expansion joints shall be designed to the FSA 0012 design standard. Use polymer-coated tie rods or grommets between the tie rods and flanges; metal-to-metal contact between the rods and flanges are not acceptable. Flanges must be completely isolated from the chemical by the molded PTFE bellows.
    4. Provide safety shields over PTFE joints and connections.
    5. Molded PTFE expansion joints acceptable manufacturers: Garlock Style 214/215, Crane Resistoflex R-series, Flexicraft Teflex Series, or approved equal.

2.03 FLEXIBLE METAL HOSE

A. Flexible Metal Hose:
    1. General:
        a. Unless otherwise specified, flexible metal hose shall be corrugated type 321 stainless steel with stainless steel fittings and shall be provided with stainless steel single braid.
        b. Attach end connections by helical crest welding.
        c. Provide bronze flexible metal hose for copper and brass systems.
    2. Braided Type:
        a. Type A: Type A (stainless steel) braided flexible metal hose shall be Senior Flexonics, or equal.
        b. Type B: Type B (bronze) braided flexible metal hose shall be Senior Flexonics, or approved equal.

2.04 FLEXIBLE TEFLON HOSE

A. Provide teflon flexible connectors consisting of molded teflon bellows and 150-pound ductile iron flanges. The flanges shall be completely isolated from the chemical by the molded teflon bellows.

B. Provide integral steel limit bolts and Monel reinforcing rings on the connectors. Provide connectors with nonasbestos gaskets. The connectors shall allow for an axial transverse movement of at least 1/2-inch, and an offset of at least 3/8-inch. The connectors shall be rated for a pressure of 130 psi, at a temperature of 70 degrees F.

C. Acceptable manufacturers: Jackson Industrial, Metraflex Teflon Expansion Joint, Garlock, modified as necessary to provide the specified features, or approved equal.

2.05 FLEXIBLE METAL HOSE LOOP

A. Flexible metal hose loops consist of two parallel sections of corrugated stainless steel metal hose and single braid with 180 degree return bend, flanged inlet and outlet connections.

B. Furnish flexible metal hose loops that provide the amount and kind of movement (axial, lateral, angular, torsional) scheduled in this Section. Provide supports at 180 degree return bend per manufacturer's recommendations.

C. For loops using hanger supports, provide seismic break-away coupling to allow separation during seismic event.

D. Acceptable Manufacturers: Metraflex; Flexicraft; Anvil International; Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Located expansion joints as specified. Location and number of guides shall be determined from EJMA Standards.

B. For piping services operating at less than 170 degree F, do not install expansion joints during times of extreme temperature or in a fully compressed or fully expanded condition.

C. For piping services operating at over 170 degree F, install expansion joints at percent elongation corresponding to installation temperature as a percent of maximum operating temperature.

D. Unless otherwise specified, expansion joints 4 inches and larger shall be furnished with control rods.

3.02 ALIGNMENT

A. Align piping systems prior to installation of expansion joints.

B. Do not use expansion joints to correct piping misalignment during installations.

C. Install expansion joints normally preset at the factory for rated axial compression and expansion in this preset condition.

D. Set control units/tie rods/restraints after all pressure testing of the piping system is complete.

PART 4 SCHEDULE

4.01 EXPANSION JOINT AND CONNECTOR SCHEDULE

A. Expansion joints and/or flexible metal hose connectors provided for specific equipment items or piping systems are specified on the following schedule. The location of piping system expansion joints and design criteria, including temperature, pressure and movement for each joint, are specified and/or shown on the drawings.

B. Expansion joints and connectors shall be provided in accordance with the following table. If a particular joint or connector is shown or specified for a given location, that more detailed selection shall apply.

Expansion Joint and Connector Schedule

Type of Expansion Joint/Connector	Type of Service/Use
Formed metal bellows; medium temperature (2.01 Medium Temperature)	Boiler exhaust, hot water, high pressure air, and gas and steel lines subjected to ambient temperature differentials sufficient to require expansion joints.
Steel expansion compensator (2.02 Steel Expansion Compensator Type)	Same type service/use as for "formed metal bellows type expansion joint" except size of piping is limited to 3 inch diameter or less.
Bronze expansion compensator (2.02 Bronze Expansion Compesator Type)	Copper piping.
Elastomer spool arch (2.02 Spool Type.)	Blower connectors and expansion joints for piping 14 inch diameter and larger.
Elastomer spherical molded (2.02 Spherical Molded Type)	Blower connectors and expansion joints for piping 12 inch diameter and less[1].
PVC (2.02 Polyvinylchloride Construction)	PVC piping.
Teflon (2.02 Teflon Construction)	RTRP (FRP) piping.
Stainless steel braided hose (2.03 Type A)	CS, LSG and mixed service connections to digester and stand pipe.
Bronze braided hose (2.03 Type B)	Air compressor discharge and pump connectors for copper lines.
Teflon flexible connector (2.04)	Connection of PVC piping to chemical storage tanks.

1. Excludes steam and chemical services.

END OF SECTION

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SECTION 40 05 07

HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies hangers and supports for all exposed piping systems specified in Section 40 05 01. This section does not include pipe supports for fire sprinkler systems or seismic restraints.

B. Scope Of Contractor Design: The Contractor shall provide the services of a "Design Professional" as specified in Section 40 05 01 to conduct all necessary piping and support design for exposed piping.
   a. Whether a design or general arrangement is shown or not, Contractor's Design Professional shall design all pipe supports, anchorage, restraints and expansion control, as specified. Where a conflict arises, Contractor's Design Professional shall present any conflict to Construction Manager for resolution.
   b. The Design Professional's work shall incorporate design criteria and other conditions as specified herein, in related sections and as shown on the drawings.
   c. Additional requirements are specified in related sections.
   d. Bidding: For purposes of bidding supports within Design Professional's Scope of Responsibility, Contractor may use the support and seismic restraint tables presented in Appendix A of this Section and information shown on the Drawings.
      1. Additional supports are required for concentrated loads, changes in direction and disassembly.
      2. Support frequency shall be determined based upon hanger load capacity, with minimum indicated factor of safety specified. Rod hanger support frequency indicated in Table A (Appendix A) shall not be represented as being sufficient to address seismic loads.
      3. Notwithstanding the Mechanical Standard Details and direction as shown on the Drawings, the full scope of supports, specified and shown, including those within the Design Professional's Scope of Responsibility is required work and differences between bid quantities and actual requirements will not be considered as extra work subject to adjustment by change order.

C. Scope Of Work By Design Engineer: Design Engineer has undertaken design details for supports and anchors for: Select piping 24" and larger. Contractor's Design Professional shall incorporate these features into the Contractor's design.
   a. Where shown, Design Engineer has also provided guidance in the form of general arrangements that may include specific types of supports or anchorage details. In addition, allowable anchor points and load capacities for potential support structures are shown or otherwise described herein.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures

2. Section 01 61 45 – Area Exposure Designations
3. Section 01 66 00 – Product Storage and Handling Requirements
4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
5. Section 03 30 00 – Cast-in-Place Concrete
6. Section 05 05 20 – Anchor Bolts
7. Section 40 05 01 – Piping Systems
8. Section 40 05 02 – Piping System Schedules
9. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
10. Section 40 05 07.13 – Seismic Restraints for Piping
11. Section 40 05 07.16 – Expansion Control for Piping
12. Section 40 05 45 – Piping System Identification
13. Section 40 42 00 – Insulation for Exposed Piping and Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Ed.
FEDSPEC WW-H-171e-78	Hangers and Supports, Pipe
MFMA-2-91	Metal Framing Standards Publication
MSS SP-69-91	Pipe Hangers and Supports - Selection and Application
MSS SP-58-93	Pipe Hangers and Supports - Materials, Design and Manufacture

1.04 DEFINITIONS [NOT USED]

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordination required with the design of piping systems, expansion joints, and expansion control and seismic restraints.
   2. Refer to Section 40 05 01 for additional coordination requirements.
   3. Refer to paragraph 1.09 Hanger and Supports Selection and Design for additional coordation requirements.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.

2. A copy of this specification section with addenda updates, and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.
3. Hanger and support locations and components shall be indicated on the piping layout drawings required by Section 40 05 01.

B. Informational Submittals:
1. Procedures: Section 01 33 00.
2. Design Professional's reports as specified in paragraph 3.05.

1.07 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

B. Refer to paragraph 1.09 Pipe Hanger and Support Selection and Design for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

1.09 PIPE HANGER AND SUPPORT SELECTION AND DESIGN

A. Hanger And Support Selection:
1. The Contractor shall cause the pipe hangers and supports to be designed and selected by the Design Professional retained under the provisions of Section 40 05 01. This provision, however, shall not relieve the Contractor of overall responsibility for this portion of the work. Hanger and support selection shall be based on the following:
   a. The Contractor shall select pipe hangers and supports as specified in the project manual. Selections shall be based upon the pipe support classifications specified in MSS-SP 69, the piping insulation thickness specified in Section 40 42 00, and any special requirements which may be specified in the project manual.
   b. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support to be used at each hanger point.
   c. Where a particular pipe support arrangement is shown, a design incorporating that arrangement shall be used.
   d. Where a particular pipe support design is shown, that design shall be used.
   e. Pipe supports shall be spaced such that pipe span deflections do not exceed 0.1-inch.
   f. Pipe support design shall incorporate applicable criteria of ASME or other recognized standard.
   g. The pipe hanger and support system shall be coordinated with the seismic restraint system specified under Section 40 05 07.13.

h. Hangers and supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration shall be given to the following conditions:
    1) Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.
    2) Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
    3) Reaction forces due to test and operational conditions.
    4) Reaction forces due to the operation of safety, relief, or other valves.
    5) Wind, snow or ice loadings on outdoor piping.
    6) Supports shall be designed to prevent transfer of the weight of piping, valves and piping appurtenances to equipment piping connections. All supports adjacent at equipment connections to piping systems shall have provisions for vertical and horizontal adjustment. Two flexible piping connections not less than one pipe diameter apart shall be provided between piping supports and any equipment piping connection.
i. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.
j. Where negligible movement occurs at hanger locations, rod hangers shall be used for suspended lines, wherever practical. For piping supported from below, bases, brackets or structural cross members shall be used.
k. Hangers for the suspension of size 2 1/2 inches and larger pipe and tubing shall be capable of vertical hanger component adjustment under load.
l. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment.
m. Where there is horizontal movement at a suspended type hanger location, hanger components shall be selected to allow for swing. The vertical angle of the hanger rod shall not, at any time, exceed 4 degrees.
n. There shall be no contact between a pipe and hanger or support component of dissimilar metals. Prevent contact between dissimilar metals when supporting copper tubing by use of copper-plated, rubber, plastic or vinyl coated, or stainless steel hanger and support components.
o. Stock hanger and support components shall be used wherever practical.
p. Fiberglass framing channel shall be provided where specified.

B. The following structural criteria shall also be applied:
1. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
2. Unless otherwise specified, pipe support components shall not be attached to pressure vessels.
3. Where critical support load requirements have been identified, limiting structural load requirements are shown.
4. Pipe support hangers, brackets etc. shall be of suitable capacity and shall be appropriate to the individual structural member that is used to support the pipe.

5. The structural integrity of existing and new members shall in no way be impacted by the placement of connections for pipe supports. For example, the tension reinforcement in reinforced concrete members shall not be impacted in any way by the placement of fasteners for pipe supports.
6. Spacing and arrangement of hangers supporting pipe shall be provided in such a manner that the loads from the pipes on existing and new structural members shall be quasi-uniform. These quasi-uniform loads shall not exceed the allowable design loads for mechanical equipment as shown on existing (not necessarily contract) drawings and as listed under Design Live Loads in the General Notes.
7. For new construction, unless otherwise shown, pipe may be supported from nearest structural element (floor, ceiling, or wall). The Design Loads for mechanical equipment, as listed in the General Notes sheet of the Structural drawings shall not be exceeded.
8. The loads and specific attachment requirements for pipe supports on new concrete Tees shall be coordinated with the Tee manufacturer and incorporated into the design of the Tees.
9. Unless otherwise specified, pipe supports from existing Tees or other roof types shall not be constructed without an evaluation of capacity and appropriate design from Contractor's Design Professional.

C. The following, project-specific criterion shall also be applied:
1. The spacing for pipe hangers shall not be less than 5 feet and shall not exceed 375 lbs of load for all existing pre-cast, Double Tee roof elements. For hangers off flanges of existing Tees, a washer shall be provided having minimum dimensions of 1/4 inch thick by 4 inch long and 4 inch wide. The design and projection of those hangers above the roof shall be coordinated with the architectural roofing system.
2. For sodium hydroxide systems, pipe supports shall be 60 percent closer than the maximum spacing indicated for plastic piping for water service.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN CRITERIA

A. Service Conditions:
1. The hangers and supports specified in this section are provided to resist pipe loads occurring primarily in the downward (gravity) direction. For the purpose of pipe hanger and support selection, this section establishes pipe support classifications based on the operating temperatures of the piping contents. Pipe support classifications are as follows:
   a. Hot Systems
      1) A - 1. 120 degrees F to 450 degrees F
      2) A - 2. 451 degrees F to 750 degrees F
      3) A - 3. Over 750 degrees F
   b. Ambient Systems
      1) B. 60 degrees F to 119 degrees F
   c. Cold Systems
      1) C - 1. 33 degrees F to 59 degrees F
      2) C - 2. -20 degrees F to 32 degrees F

B. Design:
   1. The Contractor shall cause the design of pipe hanger and support systems to be developed in conjunction with preparation of the design seismic restraints and expansion control system by the Design Professional selected in accordance with Section 40 05 07-1.01 and 1.09. The pipe system drawings specified in Section 40 05 07-1.06 shall show the hanger and support locations as well as the details of the seismic restraints and expansion control systems. The pipe hanger and support design drawings and calculations shall be prepared and signed by the design professional and shall bear the Design Professional's registration seal.

2.02 MATERIALS

A. Standard pipe supports and components shall be manufactured by B-Line, Carpenter & Patterson, Kin-Line, Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or equal. Pipe support components shall conform to the requirements of MSS SP-69 and FEDSPEC WW-H-171e.

B. Pipe support materials shall conform to the requirements of MSS SP-58. Metal framing system components shall conform to the metal framing manufacturers' Association Standard MFMA-2.

2.03 CONFIGURATION, COMPONENTS, FEATURES

A. General:
   1. Unless otherwise specified, pipe hangers and supports, structural attachments, fittings and accessories shall be hot-dip or mechanically galvanized after fabrication. Nuts, bolts and washers may be zinc-plated except for those subject to moisture or corrosive atmosphere, as specified in Section 26 05 00-1.05 Corrosive Areas as shown on the drawings, which shall be type FRP or 304 stainless steel.

B. Pipe Hangers And Supports:
   1. Pipe hangers and supports of dissimilar metals than pipe shall be insulated. Pipe hangers and supports shall support pipe in the manner recommended by the pipe manufacturer and/or applicable building or piping codes.

C. Rack And Trapeze Supports:
   1. Unless otherwise specified, trapeze and pipe rack components shall have a minimum steel thickness of 12 gage, with a maximum deflection 1/240 of the span.

D. Structural Attachments:
   1. Type A - Malleable Iron Concrete Insert: Concrete inserts shall be malleable iron and comply with MSS and FEDSPEC Type 18. Grinnell Fig. 282, Carpenter & Patterson Fig. 108, or equal.
   2. Type B - Side Beam Bracket: Bracket shall be malleable iron and comply with MSS Type 34 and FEDSPEC Type 35. Grinnell Fig. 202, B-Line B3062, or equal.
   3. Type C - Malleable Beam Clamp With Extension Piece: Clamp and extension piece shall be malleable iron, tie rod shall be steel. Beam clamp shall comply with MSS and FEDSPEC Type 30. Grinnell Fig. 218 with Fig. 157 extension piece, B-Line B3054, or equal.

4. Type D - Steel Beam Clamp With Eye Nut: Beam clamp and eye nut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 28. Grinnell Fig. 292, Carpenter & Patterson Fig. 297, or equal.
5. Type E - Framing Channel Post Base: Post bases shall be carbon steel, of standard design manufactured by framing channel manufacturer. Single channel: Unistrut P2072A, B-Line B280, or equal. Double channel: Unistrut P2073A, B-Line B281, or equal.
6. Type F - Welded Beam Attachment: Beam attachment shall be carbon steel and comply with MSS and FEDSPEC Type 22. B-Line B3083, Grinnell Fig. 66, or equal.
7. Type G - Welded Steel Bracket: Bracket shall be carbon steel and comply with MSS Type 32 and FEDSPEC Type 33 for medium welded bracket. Heavy welded bracket shall comply with MSS Type 33 and FEDSPEC Type 34.
8. Type H - Cast Iron Bracket: Bracket shall be cast iron, Carpenter & Patterson Fig. 340, or equal.
9. Type J - Adjustable Beam Attachment: Beam attachment shall be carbon steel, Carpenter & Patterson Fig. 151, B-Line B3082, or equal.
10. Type K - Double Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel double framing channel assembly, Unistrut P2542 through P2546, B-Line B297-12 through B297-36, or equal.
11. Type L - Single Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel single framing channel assembly, Unistrut P2231 through P2234, B-Line B198-6, B198-12, B196-18 and B196-24, or equal.
12. Type M - Wall Mounted Channel: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel.
13. Type N - Pipe Stanchion Floor Attachment: Baseplate shall be carbon steel with 1/2 inch minimum thickness. Anchor bolt holes shall be 1/16 inch larger than the anchor bolt diameter. The space between the baseplate and the floor shall be filled with nonshrink grout.
14. Type Q - ContinuoUs Concrete Inserts: shall be 1 5/8 by 1 3/8 Channel, cold formed 12 Ga. steel conforming to ASTM A 1001, stainless steel GR 33 or ASTM GR 33 A., hot dip galvanized conforming to ASTM A123 or A153, UNISTRUT P3200 Series, or approved equal.

E. Accessories:
1. Hanger Rods: Rods shall be carbon steel, threaded on both ends or continuous threaded and sized as specified.
2. Weldless Eye Nut: Eye nut shall be forged steel and shall comply with MSS and FEDSPEC Type 17. Eye nut shall be Grinnell Fig. 290, B-Line B3200, or equal.
3. Welded Eye Rod: Eye rod shall be carbon steel with eye welded closed. Inside diameter of eye shall accommodate a bolt diameter 1/8 inch larger than the rod diameter. Eye rod shall be Grinnell Fig. 278, B-Line B3211, or equal.
4. Turnbuckle: Turnbuckle shall be forged steel and shall comply with MSS and FEDSPEC Type 13. Turnbuckle shall be Grinnell Fig. 230, B-Line B3202, or equal.

5. Framing Channel: Framing channel shall be 1 5/8 inches square, roll formed, 12-gage carbon steel. Channel shall have a continuous slot along one side with in-turned clamping ridges. Single channel: Unistrut P1000, B-Line B22, or equal. Double channel: Unistrut P1001, B-Line B22A, or equal. Triple channel: Unistrut P1004A, B-Line B22X, or equal.

2.04 THERMAL PIPE HANGER SHIELD:

A. Thermal shields shall be provided at hanger, support and guide locations on pipe requiring insulation. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer. The thermal shield shall be the same thickness as the piping system insulation specified in Section 40 42 00. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.

B. Standard Shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof
      b. Compressive strength: 100 psi average
      c. Flexural strength: 75 psi average
      d. K factor: 0.38 at 100 degrees F mean
      e. Temperature range: 20 degrees F to 500 degrees F
   2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
   3. Connection: Shield shall have butt connection to pipe insulation. Steel jacket and insulation shall be flush with end.

C. Vapor Barrier Shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof
      b. Compressive strength: 100 psi average
      c. Flexural strength: 75 psi average
      d. K factor: 0.38 at 100 degrees F mean
      e. Temperature range: 20 degrees F to 500 degrees F
   2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
   3. Connection: Shield shall have butt connection to pipe insulation. Insulation shall extend 1 inch each side of steel jacket for vapor tight connection to pipe insulation vapor barrier.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT LOCATIONS

A. Locate hangers and supports as near as possible to concentrated loads such as valves, flanges, etc. Locate hangers, supports and accessories within the maximum span lengths specified in the project manual to support continuous pipeline runs unaffected by concentrated loads.

B. Locate at least one hanger or support within 2 feet from a pipe change in direction.

C. Locate hangers and supports to ensure that connections to equipment, tanks, etc., are substantially free from loads transmitted by the piping.

D. Where piping is connected to equipment, a valve, piping assembly, etc., that will require removal for maintenance, support the piping in such a manner that temporary supports shall not be necessary for this procedure.

E. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

3.02 INSTALLATION

A. Weld and bolt attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction. Unless otherwise specified, there shall be no drilling or burning of holes in the building structural steel.

B. 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.

C. Install items to be embedded before concrete is poured. Fasten embedded items securely to prevent movement when concrete is poured.

D. Embedded anchor bolts shall be used instead of concrete inserts for support installations in areas below water surface or normally subject to submerging.

E. Install thermal pipe hanger shields on insulated piping at required locations during hanger and support installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Rollers shall roll freely without binding.

H. Finished floor beneath Type N structural attachments and framing channel post bases shall be roughed prior to grouting. Grout between base plate and floor shall be free of voids and foreign material.

I. Baseplates shall be cut and drilled to specified dimensions prior to welding stanchions or other attachments and prior to setting anchor bolts.

J. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 ADJUSTMENTS

A. Adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Stanchions shall be adjusted prior to grouting their baseplates.

3.04 ANCHOR BOLTS

A. Anchor bolts in new concrete shall be cast in place. Refer to Section 05 05 20.

3.05 INSPECTION AND CERTIFICATION

A. The Design Professional retained by the Contractor under the provisions of Section 40 05 01 shall inspect the pipe hangers, support and restraint systems at not less than bi-weekly intervals during construction and furnish the Construction Manager with monthly reports. The Design Professional shall inspect the completed pipe hanger, support and restraint system before the Owner assumes beneficial occupancy and provide written certification, without any qualification statements, that the installation conforms to the design professional’s design and the Contract Document requirements as may be described in other Sections or on the drawings. All reports shall bear the Design Professional's seal and signature in accordance with the laws, rules and regulations of the state.

APPENDIX A: PIPE HANGERS AND SUPPORTS TABLES

TABLE A - SUPPORT SPACING AND ALLOWABLE ROD LOADS

NOMINAL PIPE SIZE (INCHES)	SUPPORT ROD SIZE AND MAXIMUM LOAD PER ROD - SEE NOTES 1 AND 2		MAXIMUM SUPPORT SPACING (FEET)				
	ROD SIZE (INCHES)	MAX LOAD (POUNDS)	STEEL	COPPER	PLASTIC SEE NOTE 4	CAST IRON SEE NOTE 5
3/8 TO 3/4	3/8	610	5	5	CONTINUOUS	---
1	3/8	610	5	5	5	---
1-1/4	3/8	610	5	5	5	---
1-1/2	3/8	610	5	5	5	---
2	3/8	610	10	5	5	
2-1/2	3/8	610	10	10	5	
3	3/8	610	10	20	5	
4	1/2	1130	10	20	5	
6	5/8	1810	15	20	5	
8	3/4	2710	15	20	5	
10	3/4	2710	20	---	5	
12	1	4960	20	---	10	
14	1	4960	20	---	---	
16	1	4960	20	---	---	
18	1	4960	20	---	---	
20	1-1/4	8000	20	---	---	
24	1-1/4	8000	20	---	---	
30	1-1/2	11630	20	---	---	

12 FEET FOR PRESSURE PIPE
10 FEET FOR SOIL PIPE

TABLE A NOTES:

1. DESIGN WEIGHT SHALL BE TWICE THE WEIGHT OF THE PIPE FULL OF WATER PLUS THE WEIGHTS OF VALVES, FITTINGS, INSULATING MATERIALS AND SUSPENDED HANGER COMPONENTS ON THE RUN OF PIPE BEING SUPPORTED.
2. ROD SIZES SHOWN ARE FOR THE SUPPORT OF A SINGLE PIPE. WHEN SUPPORTING MORE THAN ONE PIPE, ROD SHALL BE SIZED USING DESIGN WEIGHTS (SEE NOTE 1) TO DETERMINE THE TOTAL DESIGN LOAD. THE TOTAL DESIGN LOAD SHALL NOT EXCEED THE MAXIMUM LOADS IN THE TABLE ABOVE.
3. PIPE SHALL NOT HAVE POCKETS FORMED IN THE SPAN DUE TO SAGGING OF THE PIPE BETWEEN SUPPORTS CAUSED BY THE WEIGHT OF THE PIPE, MEDIUM IN THE PIPE, INSULATION, VALVES AND FITTINGS.
4. SPAN SHOWN IS FOR SCHEDULE 80 PVC PIPE AT 100°F. SPANS FOR OTHER PLASTICS, OTHER PVC PIPE SCHEDULES AND PIPES AT HIGHER TEMPERATURES SHALL BE SHORT- ENED IN ACCORDANCE WITH THE PIPE MANUFACTURER'S RECOMMENDATIONS. "CONTINUOUS" MEANS PIPE SHALL BE IN UNISTRUT OR SIMILAR CHANNEL.
5. PROVIDE A MINIMUM OF ONE HANGER PER PIPE LENGTH, WITHIN 4-INCHES OF THE BELL.
6. PIPE HANGER AND SUPPORT SELECTION SHALL BE IN ACCORDANCE WITH TABLE B (M2302) AND SPECIFICATION SECTION 15096.

TABLE B HANGER AND SUPPORT SELECTIONS

SYSTEM TEMP RANGE DEG F	INSULATION NOTE 1	PIPE ATTACHMENTS								BUILDING STRUCTURAL ATTACHMENTS			
		HORIZONTAL							VERTICAL	STEEL AND/OR MALL. IRON			
		STEEL STRAPS	STEEL BANDS	STEEL CLAMPS	CAST IRON HANGING ROLLS	CAST IRON SUPPORTING ROLLS	STEEL TRAPEZES AND RACKS	THERMAL HANGER SHIELDS	STEEL OR CAST IRON STANCHIONS	STEEL RISER CLAMPS	INSERTS	BEAM CLAMPS	WELDED AND BOLTED ATTACHMENTS	BRACKETS
HOT A-1 120 TO 450	COVERED	13	1, 2	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2	3	4, 5	8	20, 21	NONE	10					
HOT A-2 451 TO 750	COVERED	13	1	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	NONE	NONE	3	NONE	NONE	20, 21	NONE	NONE					
HOT A-3 OVER 750	COVERED	13	1	3 (ALLOY)	4, 5	8	20, 21	SEE SPEC	10	11, 12	NONE	C, D	F, J, M	B, G, H, K, L
	BARE	13	NONE	3 (ALLOY)	NONE	NONE	20, 21	NONE	NONE					
AMBIENT B 60 TO 119	COVERED	13	1, 2	3	4, 5	8	20, 21	SEE SPEC	9,10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2	3	4, 5	8	20, 21	NONE	9,10					
COLD C-1 33 TO 59	COVERED	13	1, 2, 3	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2, 3	3	4, 5	8	20, 21	NONE	10					
COLD C-2 -2 TO 32	COVERED	13	1, 2, 3	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	NONE	1, 2, 3	3	4, 5	8	20, 21	NONE	10					

TABLE B NOTES:

1. HANGERS ON INSULATED SYSTEMS SHALL INCORPORATE THERMAL HANGER SHIELDS.
2. HANGER AND SUPPORT SPACING SHALL BE IN ACCORDANCE WITH TABLE A (M2301).

TABLE C
SEISMIC RESTRAINT SPACING

NOM. PIPE SIZE	MAXIMUM SPAN BETWEEN BRACES		BRACE TYPE	MAXIMUM BRACE LENGTH
	LATERAL BRACE (FEET)	LONGITUDINAL BRACE (FEET)		
2	40	80	A1	9'-4"
2-1/2	40	80	A1	9'-4"
3	40	80	A1	9'-4"
4	40	80	A1	9'-4"
6	40	80	A1	9'-4"
8	40	40	A1	9'-4"
10	40	40	A1	9'-4"
12	40	40	A2	10'-0"
14	30	30	A2	10'-0"
16	25	25	A2	10'-0"
18	20	20	A2	10'-0"
20	16	16	A2	10'-0"
24	10	10	A2	10'-0"

(S) - STANDARD WALL

END OF SECTION

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SECTION 40 05 07.13

SEISMIC RESTRAINTS FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies seismic restraints for bracing all piping systems specified in Section 40 05 01. This section does not include seismic restraints for fire sprinkler systems.

B. Provide professional engineering services for a piping system design engineer (hereinafter the "Design Professional") as specified in Section 40 05 01, this Section, and related sections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 61 45 – Area Exposure Designations
   3. Section 01 66 00 – Product Storage and Handling Requirements
   4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   5. Section 03 30 00 – Cast-in-Place Concrete
   6. Section 05 05 20 – Anchor Bolts
   7. Section 40 05 01 – Piping Systems
   8. Section 40 05 02 – Piping System Schedules
   9. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
   10. Section 40 05 07 – Hangers and Supports for Process Piping
   11. Section 40 05 07.16 – Expansion Control for Piping
   12. Section 40 05 45 – Piping System Identification
   13. Section 40 42 00 – Insulation for Exposed Piping and Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction Manual of Steel Construction, Allowable Stress Design, 9th Edition
MFMA-2	Metal Framing Standards Publication
MFMA-101	Guidelines for the Use of Metal Framing
MSS SP-58	Pipe Hangers and Supports - Materials, Design and Manufacture

Reference	Title
MSS SP-69	Pipe Hangers and Supports - Selection and Application
MSS-SP-89	Pipe Hangers and Supports – Fabrication and Installation Practices
SMACNA	Seismic Restraint Manual—Guidelines for Mechanical Systems

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Longitudinal direction: direction parallel to the pipe axis.
   2. Lateral direction: direction perpendicular to the pipe axis.

1.05 ADMISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordination required with the design of piping systems, expansion joints, pipe supports, and expansion control and seismic restraints.
   2. Refer to Section 40 05 01 for additional coordination requirements.
   3. Refer to paragraph 1.09 Seismic Restraint Design for additional coordination requirements.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Seismic restraint system drawings and calculations as specified in paragraph 1.09 Seismic Restraint Design.
   3. Seismic restraint locations and legend as specified in paragraph 3.01.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. The Design Professional's reports and certification of final installation as specified in Section 40 05 01 and paragraph 3.03.

1.07 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

B. Refer to paragraph 1.09 Seismic Restraint Design for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01

1.09 SEISMIC RESTRAINT DESIGN

A. Design Professional:
   1. The seismic restraint system shall be designed by the Design Professional retained under Section 40 05 01. Seismic restraint details shall be designed in conjunction with preparation of pipe system hangers and drawings specified in Section 40 05 01.
   2. All drawings and work product for the seismic restraint system shall bear the design professional's registration seal and signature. The requirement, however, shall not be construed as relieving the Contractor of responsibility for this portion of the work.

B. Restraint Selection:
   1. The Contractor shall select, locate and provide seismic restraints for piping in accordance with this section. As set forth in Section 40 05 01, this work shall be the product of a Design Professional retained by the Contractor.
   2. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the restraint to be used at each point.
   3. Seismic restraints may be omitted from the following installations:
      a. Gas piping less than 1-inch inside diameter.
      b. All other piping less than 2 1/2-inch inside diameter.
   4. Piping systems shall not be braced to dissimilar parts of a building or to dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.
   5. Restraints shall be sized to fit the outside diameter of the pipe, tubing, or, where specified, the outside diameter of insulation.
   6. There shall be no contact between a pipe and restraint component of dissimilar metals. The contractor shall prevent contact between dissimilar metals when restraining copper tubing by the use of copper-plated, rubber, plastic or vinyl coated, or stainless steel restraint components.
   7. Branch lines shall not be used to brace main lines.
   8. Seismic bracing shall not limit the expansion and contraction of the piping system.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN REQUIREMENTS

A. Service Conditions:
   1. Provide seismic bracing to resist seismic loading caused by forces applied at the individual pipe's center of gravity. Designed seismic bracing for seismic loading as specified in Section 01 73 24. Seismic loading shall be assumed to be acting in the lateral, longitudinal, and vertical directions simultaneously.
   2. Provide all piping systems with seismic restraints conforming to governing state and local codes.
   3. Seismic restraints shall conform to the guidelines given in the SMACNA Seismic Restraint Manual for the Seismic Hazard Level consistent with the requirements of governing state and local codes. In case of conflict, the governing state or local code shall be followed.

2.02 MANUFACTURERS

A. Standard pipe restraints and components shall be manufactured by Carpenter & Patterson, B-Line, Kin-Line, ITT Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or approved equal.

B. Pipe restraint materials, design, manufacture, installation, and application shall conform to the requirements of MSS SP-58, MSS-SP-69, MSS-SP-89, MFMA-1, and MFMA-101.

2.03 MATERIALS

A. General:
   1. Unless otherwise specified, restraints manufactured of iron or steel, including braces, pipe and structural attachments, shall be hot-dip galvanized after fabrication.
   2. Nuts, bolts and washers, fittings and accessories, may be mechanically zinc-coated except for those subject to moisture or corrosive atmosphere, which are listed in Section 26 05 00-1.05 Corrosive Areas; those compounds shall be type 304 stainless steel.
   3. Also listed in Section 26 05 00-1.05 Corrosive Areas are corrosive areas specifically requiring fiberglass materials. In those areas, all pipe supports, anchor and seismic brace components (not just fittings and accessories) shall be made of fiberglass.

2.04 CONFIGURATION, COMPONENTS, AND FEATURES

A. Thermal Pipe Hanger Shield:
   1. Thermal shields shall be provided at seismic restraint locations on pipe requiring insulation. Thermal pipe hanger shields shall be as specified in Section 40 05 07-2.04. Stainless steel band clamps shall be provided on thermal shields at longitudinal pipe restraint locations.

PART 3 EXECUTION

3.01 PIPE RESTRAINT LOCATIONS

A. Locate the first seismic restraint on a piping system not more than 10 feet from the main riser, entrance to a building or piece of equipment.

B. Brace ductile and cast iron pipe on each side of a change in direction of 90 degrees or more. Brace or stabilize joints in risers between floors.

C. At a minimum, brace no-hub and bell and spigot cast iron soil pipe longitudinally every 20 feet and laterally every 10 feet.

D. Lateral bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24 inches of the elbow or tee of the same size.

E. Indicate seismic restraint locations and components on the piping layout drawings required by Section 40 05 01. The drawings shall bear a legend giving load information and restraint component selection at each restraint location and shall be sealed and signed by the Design Professional retained by the Contractor for design of the pipe hanger and support system under the provisions of Section 40 05 01.

3.02 INSTALLATION

A. Use rod stiffener assemblies at seismic restraints for hanger rods over 6 inches in length. Use a minimum of two rod stiffener clamps on any rod stiffener assembly.

B. Install lateral and longitudinal bracing between 45 degrees above and 45 degrees below horizontal, inclusive, relative to the horizontal centerline of the pipe.

C. Weld and bolt attachments to the building structural steel in accordance with the requirements of AISC M011. There shall be no drilling or burning of holes in the building structural steel without approval of the Engineer.

D. Use embedded anchor bolts instead of concrete inserts for seismic brace installations in new concrete areas below water surface or normally subject to submerging. Otherwise, design and provide anchor bolts in accordance with Section 05 05 20.

E. Install thermal pipe hanger shields on insulated piping at required locations during restraint installation. Make butt joint connections to pipe insulation at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Restraint components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Rollers shall roll freely without binding.

H. Provide plastic or rubber end caps at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 INSPECTION AND CERTIFICATION

A. The Design Professional retained by the Contractor under the provisions of Section 40 05 01 shall inspect the seismic restraint system at not less than bi-weekly intervals during construction and furnish the Engineer with monthly reports.

B. The Design Professional shall inspect the completed seismic control system before the Owner assumes beneficial occupancy and provide written certification in accordance with Section 40 05 07 requirements.

END OF SECTION

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SECTION 40 05 07.16

EXPANSION CONTROL FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies expansion control for the piping systems specified in paragraph 2.01 Service Requirements. This section addresses pipe anchorage, pipe guides, and expansion control by either expansion joints or pipe deflection.

B. Provide professional engineering services for a piping system dsign engineer (hereinafter the "Design Professional") as specified in Section 40 05 01, this Section, and related sections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 61 45 – Area Exposure Designations
   3. Section 01 66 00 – Product Storage and Handling Requirements
   4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   5. Section 03 30 00 – Cast-in-Place Concrete
   6. Section 05 05 20 – Anchor Bolts
   7. Section 09 90 00 – Coating Systems
   8. Section 40 05 01 – Piping Systems
   9. Section 40 05 02 – Piping System Schedules
   10. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
   11. Section 40 05 07 – Hangers and Supports for Process Piping
   12. Section 40 05 07.13 – Seismic Restraints for Piping
   13. Section 40 05 45 – Piping System Identification
   14. Section 40 42 00 – Insulation for Exposed Piping and Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Edition
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes

Reference	Title
EJMA STDS	Standards of Expansion Joint Manufacturers' Association, Edition No. 5

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

Term	Definition
Expansion joint	Any device containing one or more bellows used to absorb dimensional changes.
Main anchor	An attachment between a structure and a pipe which must withstand the full pipeline thrust due to pressure, pipe bending, pipe compression, flow, spring forces, pipe and contents weight and other pipe forces.
Intermediate anchor	An attachment between a structure and a pipe which withstands the same forces as a main anchor except the pressure forces.
Sliding anchor	An attachment between a structure and a pipe which absorbs forces in one direction while permitting motion in another.
Pipe guide	A device fastened to a structure, which permits the pipeline to move freely in only one direction, along the axis of the pipe.
Pipe section	That portion of pipe between two anchors.
Planar pipe guide	A device fastened to a structure, which permits transverse movement or bending of the pipeline in one plane.
Lateral direction	Direction perpendicular to the pipe axis
Longitudinal direction	Direction parallel to the pipe axis

1.05 ADMISTRATIVE REQUIREMENTS

A. Cordination:
   1. Coordination required with the design of piping systems, expansion joints, pipe supports, and expansion control and seismic restraints.
   2. Refer to Section 40 05 01 for additional coordination requirements.
   3. Refer to paragraph 1.09 Expansion Control Design for additional coordation requirements.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   3. Identify expansion control locations and components indicated on piping layout drawings as specified in Section 40 05 01.
   4. Expansion control schedules as specified in paragraph 4.01.

B. Information Submittals:
   1. Procedures: Section 01 33 00.
   2. Anchor bolt calculations in accordance with Section 05 05 20 requirements.

3. The Design Professional's reports and final certification, as specified under paragraph 3.02

1.07 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

B. Refer to paragraph 1.09 Expansion Control Design for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

1.09 EXPANSION CONTROL DESIGN

A. Design:
   1. The expansion control system shall be designed by the Contractor's Design Professional selected under Section 40 05 01.
   2. Expansion control details shall be designed in conjunction with preparation of pipe system hangers and seismic restraint systems drawings specified in Section 40 05 01.
   3. The resulting drawings, calculations, and work product for the expansion control system shall bear the Design Professional's registration seal and signature. The requirement, however, shall not be construed as relieving the Contractor of responsibility for this portion of the work.

B. Design Guidelines:
   1. The Design Professional shall use the following guidelines in preparation of the designs and calculations specified in paragraph 1.09 Expansion Control Design.
      a. The difference between the minimum and maximum temperatures listed in the table in paragraph 2.01 Service Requirements shall be used for calculating pipe expansion.
      b. Published coefficients of thermal expansion for pipe materials shall be used for the listed temperature range. The source of the coefficients of expansion used in the calculations shall be included with the information provided as Product Data.
      c. Expansion control systems shall be designed for maximum reliability. Unless otherwise indicated on the Drawings, "L", "U", or "Z" bends shall be employed to control expansion in preference over expansion joints.
      d. Expansion control systems using pipe bends shall be designed to limit bending stress in the pipe associated with deflection at the worst case temperature difference. The maximum allowable bending stress shall be 1/3 of the yield stress for the pipe material. If loading conditions or uncertainties warrant, a lower allowable stress value shall be used. A recognized pipe bending stress calculation method and documentation supporting its use shall be provided as Product Data.

e. The requirements set forth in Section 40 05 06.23 shall prevail if expansion joints are used. Expansion control design for expansion joints shall conform to the guidelines given in the Standards of The Expansion Joint Manufacturers Association, Inc. (EJMA).

f. If the Design Professional chooses to use expansion control or pipe support methods that involve higher loadings on the structure than are specified and/or shown on the drawings, the Construction Manager shall be notified in the submittal required in Section 40 05 01. The requested loads shall be listed and the Construction Manager will redesign the structure as necessary at the Contractor's expense.

g. The test pressures listed in the Piping Systems Schedules sheets shall be used when calculating pressure forces.

h. Pipe guides or planar pipe guides shall be provided to control the movement of pipes when "L", "U", or "Z" bends are used for expansion control. The guides shall be located as indicated in EJMA standards. An alternative recognized standard may be used for this purpose only upon approval by the Construction Manager.

i. For piping systems with potentially large loads, recommended main anchor locations are shown on the drawings. Intermediate anchors shall be provided as needed. Maximum forces that the structure can withstand at the main anchor points are noted on the drawings. Anchors shall be designed to attach to the structure and solidly to the pipe. Pipe clamps or U-bolts are not allowed unless they are designed to withstand the forces imposed upon the anchor and have stops welded to the pipe so that the pipe cannot slip in the anchor.

j. Anchors and guides shall be coordinated with the pipe support systems specified in Section 40 05 07 and seismic restraints specified in Section 40 05 07.13.

k. The design of the expansion control, pipe support and seismic restraints for the listed piping systems shall be integrated to provide maximum flexibility for maintenance access to equipment, appurtenances such as valves etc., and to the pipe itself.

l. The piping layout indicated shall be reviewed in relation to, surrounding structures, adjacent piping and equipment before selecting the anchors, guides, and expansion control method to be used at each point.

m. There shall be no metal-to-metal contact between a pipe and restraint component of dissimilar metals.

n. Branch lines shall not be used to anchor main lines.

o. For elevated pipe sections, fabricated support frames or other appropriate structures shall be designed to withstand the specified loads plus gravity and seismic loads. The supports shall be designed to provide access to equipment, walkways, gates, and other piping.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN REQUIREMENTS

A. Service Conditions:

1. Expansion control as specified in this section shall be provided to control pipe movements and loads occurring as a result of pipeline temperature changes.
2. Those piping systems listed in the following table shall be provided with expansion control conforming to good engineering practice.

Piping system	Minimum temperature, degrees F	Maximum temperature, degrees F
A, AA, BA, CA, IA, SA	17 (exterior –20)	300 (exterior 200)
CS, DS, LSG, MSG (and combinations)	30 (exterior –20)	120
EE	-20	1000
GRR/S	-20	200
HW, HRR/S	70	230
Unlisted Piping (exterior)	-20	120
Unlisted Piping (interior)	30	120

2.02 MATERIALS

A. Unless otherwise specified, anchors, and guides shall be manufactured of iron or steel, including braces, pipe and structural attachments, and shall be hot-dip galvanized after fabrication. Supports cast integrally with cast iron fittings are specifically prohibited for use in any application where shear forces may be imposed on the support.

B. Structural anchors may be fabricated from structural steel and coated as specified in Section 09 90 00.

C. Nuts, bolts and washers may be zinc-plated except for those subject to moisture or corrosive atmosphere, as specified in Sections 26 05 00-1.05 Corrosive Areas and 1.05 Hazardous (Classified) Areas, which shall be Type 304 stainless steel.

D. Also listed in Section 26 05 00-1.05 Hazardous (Classified) Areas are corrosive areas specifically requiring fiberglass materials. In those areas, all pipe support, anchor and brace components (not just fittings and accessories) shall be made of fiberglass.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the expansion control system in accordance with the drawings required in paragraph 1.09 Expansion Control Design.

B. Metal-to-metal contact between a pipe and pipe anchor of dissimilar metals is not permitted.

C. Weld and bolt attachments to the building structural steel in accordance with the requirements of the AISC Manual of Steel Construction. There shall be no drilling or burning of holes in the building structural steel without approval of the Construction Manager.

D. Provide embedded anchor bolts instead of concrete inserts, wedge anchors, expansion anchors, adhesive, or other non-embedded type of anchor for expansion control installations in areas below water surface or normally subject to submergence. Anchor bolt installation as specified in Section 05 50 20.

E. Install thermal pipe hanger shields on insulated piping at required locations during guide installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Roller assemblies are specified in the Drawings. Roller shall roll freely without binding.

H. Provide plastic or rubber end caps at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.02 INSPECTION AND CERTIFICATION

A. The Design Professional retained by the Contractor under the provisions of Section 40 05 01 and this Section shall inspect the completed expansion control system at not less than bi-weekly intervals during construction and furnish the Construction Manager with monthly reports.

B. The Design Professional shall inspect the completed expansion control system before the Owner assumes beneficial occupancy and provide written certification in accordance with Section 40 05 07 requirements.

PART 4 SCHEDULES

4.01 EXPANSION CONTROL SCHEDULES

A. General: Anchor, guide, and expansion joint locations shall be indicated on the piping layout drawings required by Section 40 05 01 and paragraph 1.09 Expansion Control Design. In addition, schedules shall be prepared as specified below.

B. Anchors:
   1. The anchor schedule shall list as a minimum:
      a. Anchor Point Label
      b. Pipe Size and Service
      c. Contract Drawing No.
      d. Layout Drawing No.
      e. Forces
      f. Load, pounds
      g. Direction
      h. Anchor Description
      i. Remarks

C. Guides:
   1. The guide schedule shall list as a minimum:
      a. Guide Label
      b. Pipe Size and Service
      c. Contract Drawing No.
      d. Layout Drawing No.

e. Guide Description
f. Remarks

D. Expansion Joints:
1. The expansion joint schedule shall list as a minimum:
a. Expansion Joint Label
b. Pipe Size and Service
c. Contract Drawing No.
d. Layout Drawing No.
e. Movement, inches
1) Lateral movement
2) Compression movement
3) Extension movement
4) Angular movement
f. Maximum Spring Force, pounds
g. Test Pressure, PSIG
h. Pressure Force, pounds
i. Total Forces
j. Load, pounds
k. Direction
l. Expansion Joint Description
m. Special Features
n. Remarks

END OF SECTION

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SECTION 40 05 17

COPPER PROCESS PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies copper pipe, tube, and fittings.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 66 00 – Product Storage and Handling Requirements
   3. Section 40 05 01 – Piping Systems
   4. Section 40 05 06.16 – Mechanical Pipe Couplings
   5. Section 40 06 02 – Piping System Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM B32	Solder Metal
ASTM B88	Seamless Copper Water Tube

1.04 SUBMITTALS

A. Action Submittals:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Manufacturers' product data, catalog cuts, typical installation details, and dimensions demonstrating compliance with the requirements of this Section.

3. Indicate on the submittal each piping system where the product will be used.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturers' certificates of compliance with specified industry standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for Shipment and Storage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are listed below for double ferrule compression fittings.
   1. Swagelok.
   2. Gyrolok.
   3. Equal.

2.02 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards identified in the Piping System Schedules specified in Section 40 05 02 .00 through Section 40 05 02.99.

B. Couplings and Fittings.
   1. Double ferrule compression fittings capable of holding the full bursting strength of connected tubing.
   2. Provide tapered piping reducers/enlargers. Bushing type adapters are not permitted.

C. Joint Solder
   1. Except where otherwise specified in the Piping System Schedules, use ASTM B32, Alloy Grade Sn95 solder for general use in copper piping.
   2. ASTM B32 Alloy Grade E, or Silvabrite 100, for high pressure and high temperature services, where specified.
   3. Brazing, for saturated steam, AWS Classification BCuP-5 (AWS A5.8/A5.8M) or Sil-Fos® 15, where specified.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cleaning.
   1. Remove foreign material from the pipe interior prior to assembly. Swab the pipe interior.
   2. Deburr pipe end and sand using fine emery cloth.

B. Dielectric protection.

1. Copper tubing or fittings in contact with dissimilar metal piping, reinforcing steel, or other dissimilar metal at any location is not permitted.
2. Make electrical checks to assure no contact is made between copper tubing and ferrous elements.
3. Wherever electrical contact is demonstrated by such tests, provide dielectric protection as specified in Section 40 05 06.16.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01.

3.03 COMPONENT TEST PHASE

A. Per Section 40 05 01.

END OF SECTION

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SECTION 40 05 19

DUCTILE IRON PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies ductile iron pipe and fittings.

1.02 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures

B. Section 01 66 00 – Product Storage and Handling Requirements

C. Section 40 05 01 – Piping Systems

D. Section 40 05 02 – Piping System Schedules

E. Section 40 05 06.16 – Mechanical Pipe Couplings

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings
ASTM C150	Portland Cement
ASTM A716	Standard Specification for Ductile Iron Culvert Pipe
AWWA C104	Cement-Mortar Lining for Ductile- Iron and Gray-Iron Pipe
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings
AWWA C111	Rubber-Gasket Joints for Ductile- Iron and Gray-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges
AWWA C116	Protective Fusion-Bonded-Epoxy Coating for the Interior and Exterior Surfaces for Ductile-Iron and Gray-Iron Fittings.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast
AWWA C153	Ductile-Iron Compact Fittings
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances.
AWWA C606	Grooved and Shouldered Type Joints
ISO 8179-1	Ductile Iron Pipes – Externa Zinc-based Coating - Part 1: Metallic Zinc with Finishing Layer

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Manufacturer's product data, catalog cuts, dimensions and materials. Indicate each Piping System Schedule where the product will be used.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Certifications indicated in the following documents:
      a. ASTM A716, sworn statement of inspection and certification.
      b. AWWA C110, certification of inspection and testing.
      c. AWWA C111, record of specified tests.
      d. AWWA C115, affidavit of compliance.
      e. AWWA C151, manufacturer's statement and affidavit of compliance.
      f. AWWA C606, affidavit of compliance.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards identified in Section 40 05 02 and related sections.

B. Pipe.
   1. Provide increased wall thickness where specified on the Drawings.

2.02 PIPE LINING

A. Provide pipe and fittings with lining as specified in Piping System Schedules in Section 40 05 02.00 through 40 05 02.99 or on the Drawings. Requirements for each lining type are specified in this Section.
   1. Cement Mortar Lining.
      a. Factory applied.
      b. Line pipe and fittings with cement mortar as specified in AWWA C104.
      c. Cement shall be ASTM C150, Type II or V, low alkali, containing less than 0.60 percent alkalis
      d. Patch field welds, cuts, connections, and damaged lining in accordance with AWWA C104.
   2. Ceramic Epoxy
      a. Factory applied.
      b. Line pipe and fittings with amine cured novolac epoxy containing at least 20 percent ceramic quartz pigment.
      c. 40 mils minimum thickness.
      d. Candidate Manufacturers:
         1) Protecto 401
         2) Approved Equal
   3. Unlined
      a. Provide pipe and fittings with a bare metal (no coating) interior.

2.03 PIPE COATING

A. Provide pipe with coating as specified in Piping System Specification Sheets in Section 40 05 02. Requirements for each coating type are specified in this Section.
   1. Asphaltic Coating
      a. Factory applied.
      b. Coat pipe and fittings with 1 mil, minimum, of asphaltic material as specified in AWWA C151.
   2. Zinc Coating with Asphaltic Top Coat
      a. Factory applied.
      b. Coat pipe and fittings with a layer of arc-sprayed zinc per ISO 8179-1. Zinc applied at not less than 200 g/m^2 of pipe surface area. Apply a finishing layer asphaltic topcoat per AWWA C151.
   3. Polyethylene Encasement.
      a. Field installed.
      b. Encase pipe and fittings in polyethylene wrap as specified in AWWA C105.
      c. Polyethylene tubing shall be Anti-microbial, Low Density Polyethylene (LDPE) or High Density Polyethylene (HDPE):
         1) LDPE: 8-mil linear low density polyethylene film meeting the requirements of AWWA C105, impregnated with ½ percent NM-100 anti-microbial compound. Fulton Enterprises Biofilm, or Approved Equal.

2) HDPE: 4-mil high-density, cross-laminated polyethylene film meeting the requirements of AWWA C105.

d. Seam/Joint Tape – Acceptable manufacturer:
   1) Polyken No. 900 (polyethylene).
   2) Scotchwrap No. 50 (polyvinyl).
   3) Approved Equal.

4. V-Bio Enhanced Polyethylene Encasement
   a. Field installed
   b. Encase pipe and fittings in polyethylene tubing as specified in AWWA C105.
   c. Three layer, co-extruded, linear low density polyethylene wrap.
   d. 8 mils minimum wrap thickness
   e. Inner surface of polyethylene wrap infused with anti-microbial biocide and corrosion inhibitor.
   f. Candidate Manufacturers:
      1) V-Bio
      2) Approved Equal
5. Epoxy Primer.
   a. Factory or shop applied.
   b. Coat pipe and fittings with Amide or Polyamide cured epoxy, 4 to 6 mils DFT
5. Uncoated
   a. Provide pipe and fittings with a bare metal (no coating) exterior.

2.04 FUSION-BONDED EPOXY LINING AND COATING FOR FITTINGS

A. Factory or shop applied.

B. Fusion Bonded Epoxy lining and coating per AWWA C116.

2.05 JOINTS, AND COUPLINGS

A. Push-On (PO) Joint (Unrestrained)
   1. Rubber ring compression gasket, push-on type joints conforming to AWWA C111.
   2. 5 degree deflection at rated operating pressure for joints on 4-inch through 30-inch pipe.
   3. Candidate manufacturers:
      a. American Cast Iron Pipe Company Fastite
      b. U.S. Pipe Tyton Joint
      c. Approved Equal

B. Restrained Push-On (RPO) Joint
   1. Restrained, rubber ring compression gasket, push-on joints conforming to AWWA C111

2. Restrained by the interference of metallic rings, bolts, locking segments or other interlocking components with flanges, lugs, beads, grooves or retainer rings that are integrally cast into or welded onto both ends of the joint. Restrained joints with gripping wedges, or gripping gaskets, radial pads, or other devices that penetrate, grip, or embed in the pipe material to resist axial thrust loads are not acceptable.
3. Candidate manufacturers:
    a. American Cast Iron Pipe Company, Flex-Ring or Lok-Ring
    b. U.S. Pipe, TR Flex or HP LOK
    c. Approved Equal

C. Mechanical Joint (MJ)
1. Mechanical Joints per AWWA C110 and AWWA C111.

D. Restrained Mechanical Joint (RMJ)
1. Restrained by tie-rods/bolts tying the gasket gland to a second retainer/follower gland behind a welded ring on the spigot end of the joint. Restrained joints with gripping wedges, or gripping gaskets, radial pads, or other devices that penetrate, grip, or embed in the pipe material to resist axial thrust loads are not acceptable.
2. Fully restrained mechanical joints for above or below ground service conforming to AWWA C110 and AWWA C111.
3. Candidate manufacturers:
    a. American Cast Iron Pipe Company, Mechanical Joint Coupled Joint
    b. U.S. Pipe, MJ HARNESS-LOK
    c. Approved Equal

E. Grooved couplings (CGRV) and fittings.
1. When pipe wall thickness does not meet the minimum requirements of AWWA C606 for rolled or cut groove joints, provide shouldered ends per the requirements of AWWA C606.
2. Candidate manufacturers.
    1) Victaulic
    2) Gruvlok
    3) Approved equal.
3. Grooved end flanged coupling adapters candidate manufacturers:
    a. Victaulic Style 341
    b. Approved Equal
4. Grooved end transition couplings to steel pipe candidate manufacturers:
    a. Victaulic Style 307
    b. Approved Equal

F. Bell and Ball Spigot Flexible (BABS) Joint.
1. Boltless type with retainer lock to prevent rotation after assembly
2. Up to 15 degrees of deflection at operating pressure
3. Candidate manufacturers.
    a. Flex-Lok Joint by American Cast Iron Pipe

b. USIFlex by US Pipe
c. Approved equal.

G. Sleeve/Transition Coupling.
1. When connecting new ductile iron piping to existing piping, field verify outside diameters of existing pipe prior to connection. See drawings for location and installation requirements.
2. Candidate Manufacturers.
a. Romac, "501"
b. JCM, "212"
c. Smith-Blair, "461"
d. Approved Equal

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Follow piping routes specified on the drawings as closely as possible. Submit proposed deviations in accordance with Section 01 33 00.
2. Install pipe in accordance with AWWA C600.
3. Make connections to existing structures and manholes so that the finished work will conform as nearly as practicable to the requirements specified for new manholes, including necessary concrete work, cutting and shaping. Shape concrete mortar within any structure and manhole as specified.

B. Insulating Sections: Where a metallic nonferrous pipe/appurtenance connects to ferrous pipe/appurtenance, provide an insulating section per Section 40 05 06.16.

C. Anchorage: Provide as specified on the Drawings.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01.

3.03 COMPONENT TEST PHASE

A. Buried Piping: Test hydrostatic pressure in accordance with Section 5 of AWWA C600, using the test pressures and allowable leakage specified in Section 40 05 01.

B. Exposed and Concrete Encased Piping: Conduct hydrostatic pressure tests in accordance with Section 40 05 01.

3.04 POLYETHYLENE ENCASEMENT

A. Install polyethylene as specified in AWWA C105 and within this Section.

B. Potable Water Pipe: Single wrap, 4-mil high density polyethylene.

C. Wrapping:
   1. Wrap buried pipe, fittings, valves, and couplings.
   2. Prior to the placing of concrete, wrap fittings that require concrete backing.
   3. Wrap the polyethylene tube seams and overlaps and hold in place by means of a 2-inch-wide plastic backed adhesive tape.
   4. The tape shall be such that the adhesive shall bond securely to both metal surfaces and polyethylene film.
   5. Bedding and initial backfill for polyethylene wrapped pipe shall be a well-graded granular material to avoid cutting or damaging the polyethylene tube during placement and backfilling.

END OF SECTION

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SECTION 40 05 23

STAINLESS STEEL PROCESS PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies stainless steel pipe and fittings.

1.02 RELATED SECTIONS

A. Section 40 05 01 – Piping Systems

B. Section 40 05 02 –Piping System Schedules

1.03 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B31.3	Process Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM A480	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
AWWA M11	Steel Pipe-A Guide for Design and Installation
AWWA C227	Bolted, Split-Sleeve Restrained and Non-Restrained Couplings for Plain-End Pipe
AWWA C606	Grooved and Shouldered Joints
CSA W48.3	Low Alloy Steel Covered Electrodes for Shielded Metal Arc Welding

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.

2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The CITY shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Piping layout drawings as specified in Section 40 05 01.
4. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.
5. Pipe wall thickness calculations for pipe fabricated per AWWA C220. Demonstrate the maximum permissible internal design pressure in the pipe based on the wall/shell thickness specified in the Piping System Schedule for the associated Process Service and pipe size and the support and/or bedding conditions specified on the Drawings. Steel pipe design calculations conform to AWWA M11.
6. Pipe wall thickness and reinforcement calculations for fittings fabricated per AWWA C226. Demonstrate that the maximum permissible internal design pressure for fabricated fittings matches or exceeds the maximum permissible internal design pressure in the connecting pipe for the support and/or bedding conditions specified on the Drawings. Fabricated steel pipe fitting design calculations conform to AWWA M11.
7. Calculations for any pipe and fittings that are not fabricated per one of the components standards listed in the specified ASME B31 code.
8. Submit calculations for engineered flange face rings in accordance with Appendix D of ASME Section VIII Division 1.

B. Informational Submittals:
1. Procedures: Section 01 33 00.
2. Manufacturers' certificates of compliance with specified industry standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for Shipment and Storage.

B. Deliver pipe and fittings with end protectors in place. Do not remove protectors until materials are about to be installed.

C. Prevent carbon steel contamination of stainless steel pipe and fittings during storage, handling, fabrication, and installation.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards specified in Piping System Schedules (Section 40 05 02.00 through Section 40 05 02.99) and this Section.

B. Pipe.
   1. Use pickled and annealed sheet or plate for manufacture of fabricated stainless steel pipe.
   2. Finish.
      a. 8-gage through 16-gage material: No. 1 or 2B per ASTM A480.
      b. 3/16-inch and heavier plate material: No. 1 mill finish per ASTM A480, "Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Blast Cleaned or Pickled."

C. Shop-fabricated stainless steel pipe and fittings.
   1. Furnished by a single manufacturer who is experienced and qualified in the manufacture and fabrication of the items to be provided.
   2. Manufacture using Weld Procedure Specifications (WPS) that have been qualified under ASME Section IX. Document qualifications in Procedure Qualification Reports (PQR). Use only certified welders who have successfully completed performance qualification tests per ASME Section IX for manufacture of stainless steel pipe.

D. Flanges.
   1. Plate steel backing ring flanges, AWWA C207 Class D minimum thickness.
   2. Ductile iron backing ring flanges with the following flange thicknesses.

Flange Size, in	Flange Thickness, minimum, in.
3	1/2
4	9/16
6 thru 10	5/8
12 thru 16	3/4
18 thru 22	7/8
24 thru 30	1
36	1-1/8
42	1-1/4
46 to 54	1-3/8
60	1-1/2

   3. Stub ends.
      a. Wall thickness equal to or greater than pipe or fitting to which it is welded.
      b. Lap face/gasket mating surfaces clean, free of debris, with welds ground flush and surface roughness between 3.18 and 12.7 microns RMS.

E. Fittings.
   1. Double ferrule compression fittings capable of holding the full bursting pressure of connected tubing.
   2. Candidate manufacturers for double ferrule compression fittings.
      a. Swagelok.
      b. Gyrolok.
      c. Approved Equal.
   3. Provide straight tapered reducers. Flanged & flued reducers and bushing type adapters are not permitted.
   4. Pressure rating and thickness of elbows, tees, crosses, and wyes equal to or greater than connecting pipe.

F. Grooved couplings and fittings.
   1. Flexible and rigid coupling with pipe grooves compliant with AWWA C606.
   2. When pipe wall thickness does not meet the minimum requirements of AWWA C606 for rolled or cut groove joints, provide shoulder ends per the requirements of AWWA C606.
   3. Candidate manufacturers.
      a. Victaulic
      b. Gruvlok
      c. Approved equal.

G. Bolted split sleeve couplings.
   1. AWWA C227 compliant sleeve with single or double arch cross section of the same material as pipe. Body thickness equal to or greater than that of connecting pipe wall thickness.
   2. Candidate manufacturers.
      a. Victaulic, Style 231S through 234S.
      b. Approved equal.

2.02 SHOP FABRICATION

A. Metal forming processes.
   1. Use pinch rolls with a hard chrome finish to form cylinders. Thoroughly clean the rolls using Avesta BlueOneTM 130 Pickling Paste or approved equal, prior to roll forming the pipe. Alternatively, provide a protective barrier between the stainless steel plate/sheet and the plate rolls during the forming process.
   2. Provide a protective barrier between pipe welding rollers and the stainless steel pipe cylinder. Alternately, new rollers or rollers that have been turned down on a lathe to provide a new and clean working face may be used.

B. All saws, drills, files, wire brushes, grinding wheels, etc. will be free of carbon contamination and designated for stainless steel use only.

C. Provide nonferrous, stainless steel, or rubber-lined pipe storage and fabrication racks.

D. Use nylon slings or straps for handling stainless steel piping.

E. Preparation of surfaces to be welded.
   1. Surfaces of joints to be welded are to be free from mill scale, slag, grease, oil, paint, rust, and other foreign material.
   2. Use only stainless wire wheels and grinding wheels that have not come into contact with carbon steel.
   3. Flame cutting or any use of oxy-acetylene gas cutting tools is prohibited. Use plasma arc torch with a nitrogen or argon-hydrogen carrier gas, laser or waterjet processes for cutting and plate beveling.
   4. Air arc and gas backgouging are prohibited. Use grinding and plasma gouging methods to achieve full penetration welds.

F. Welding.
   1. Welding and production processes are to conform to ASME B31.3.
   2. Use of Solar Flux is prohibited.
   3. Use of FCAW welding is prohibited.
   4. Pipe and fittings with wall thickness up to 11-gage (1/8-inch): weld using the GTAW process.
   5. Pipe and fittings with wall thicknesses greater than 1/4-inch may be welded using an automated SAW process.
   6. Pipe and fittings with wall thickness greater than 11-gage (1/8-inch): Bevel and complete root pass using the GTAW process, followed by subsequent passes with the GTAW, GMAW, or Metallic Arc SMAW process.
   7. Filler material:
      a. Add only ELC wire grades to provide a cross section at the weld equal to or greater than the parent metal.
      b. SMAW electrodes to conform to CSA W48.3.
   8. Make weld deposit smooth and evenly distributed and with a crown of no more than 1/16-inch on the I.D. and 3/32-inch on the O.D. of the piping. Concavity, undercut, cracks, or crevices are not permitted.
   9. Full penetration butt welds: provide inert gas shielding to the interior and exterior of the joint.
   10. Lap joints: provide full thickness seal welds on both joints.

G. Remove excessive weld deposits, slag, spatter, and projections by grinding. Grind welds smooth on gasket surfaces. Tack welds, clips, and other attachments.
   1. Repair nicks, gouges, notches, and depressions in the base metal in the area before the joint weld is made.
   2. Remove tack welds, clips, and other attachments and repair defects, except where the tack welds occur within the weld area and these tack welds do not exceed the size of the completed weld. Remove cracked tack welds.
   3. Grind those areas to be repaired down to clean metal and then repair by building up with weld metal. Grind the repaired areas smooth to form a plane surface with the base metal.

H. Defects and repairs.
   1. Remove welds with cracks, slag inclusions, porosity, undercutting, incomplete penetration, or which are otherwise deficient in quality or made contrary to any provisions of these specifications, by chipping or grinding throughout their depth to clean base metal.
   2. Do not perform calking or peening of welds to correct defects.
   3. Enlarge welds found deficient in dimension but not in quality by additional welding after thoroughly cleaning the surface of previously deposited metal and the adjoining plate.
   4. Remove weld deposits, slag, weld spatter, and projections into the interior of the pipe by grinding.

I. Finish.
   1. Treat all welded joints with Avesta BlueOne™ 130 Pickling Paste or approved equal and rinse with clean water.
   2. If rusting of embedded iron occurs, pickle the affected surface with Avesta BlueOne™ 130 Pickling Paste or approved equal.
   3. Rinse clean using Avesta FinishOne Passivator 630 or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Field Installation Weather conditions.
   1. Perform welding only when the surfaces are clean and completely free of any moisture or mineral deposits. Protect pipe and fittings from salt water spray or deposition or clean and protect pipe and fitting joints prior to welding.
   2. Do not weld the pipe during periods of high winds or rain unless the areas being welded are properly shielded.

B. Field welding.
   1. Use couplings and prefabrication of pipe systems at the factory to minimize field welding to the greatest extent possible. Pipe butt welds may be performed at the job site, providing the butt welds are performed only with an inert gas shielded process and that the welding requirements of this Section are rigidly adhered to.
   2. On the interior and exterior of the pipe, remove all residue, oxide, and heat stain from any type of field weld and the affected areas adjacent by the use of stainless steel wire brushes, followed by cleaning with an agent such as Avesta BlueOne™ 130 or approved equal, followed by complete removal of the agent.

C. Use wooden scaffolding and/or ladders if possible to gain access to work areas. If metal scaffolding and/or ladders must be used, tape or otherwise shield the contact points between scaffolding/ladders and the stainless steel.

D. After installation, wash and rinse all foreign matter from the piping surface. Adhere to the passivation manufacturer's recommendations and local regulations for safety and disposal of any waste chemicals.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01 and as specified herein.

B. Paint all steel or iron flanges, couplings, and appurtenances in accordance with Section 09 90 00. Painting of the stainless steel pipe is not required.

C. Restore areas damaged or discolored by field welding or handling, iron contamination or soiled to a uniform surface finish and consistently clean surface with methods specified for shop fabrication.

D. Identifying spool piece marks shall be removed with paint thinner or solvents and the entire stainless steel surface shall be washed with detergent and hot water and rinsed clean.

3.03 COMPONENT TEST PHASE

A. Per Section 40 05 01.

END OF SECTION

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SECTION 40 05 24

STEEL PROCESS PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies steel pipe and fittings.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.3	Malleable Iron Threaded Fittings, Class 150 and 300
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket-Welding and Threaded
ASTM A36/A36M	Structural Steel
ASTM A47	Ferritic Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106 REV A	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A283/A283M REV A	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
ASTM A536	Ductile Iron Castings
ASTM A570/A570M	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A572/A572M REV B	High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe--4 In. and Larger-- Shop Applied

Reference	Title
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services--Sizes 4 In. Through 144 In.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA M11	Steel Pipe--A Guide for Design and Installation
SSPC-SP10	Near-White Blast Cleaning

B. Testing:
   1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, or AWWA C200 as specified in Section 40 05 01.

B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.

C. Steel pipe for 5ft outside yard piping buried to meet requirements of AWWA C200, Gr 36 ASTM A1018.

2.02 PIPE MANUFACTURE

A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 40 05 01. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified.

B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24 inch diameter and 1/4 inch for pipe 26 inch diameter and larger. Increased shell thickness shall be provided where specified.

2.03 CONNECTIONS

A. Connections shall be as specified in Section 40 05 01 and shall conform to Section 40 05 06.16. Coating for buried connections shall be as specified in Section 40 05 06.16-2.06.

2.04 FITTINGS AND APPURTENANCES

A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.

B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208.

C. Fittings for grooved end piping systems shall be full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.

D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.05 PIPE LINING

A. Epoxy:
   1. Unless otherwise specified, pipe and fittings shall be lined with a liquid epoxy as specified in AWWA C210 with the following exceptions:
      a. No coal tar products shall be incorporated in the liquid epoxy.
      b. The curing agent may be an amidoamine as well as the other curing agents listed in AWWA C210.
   2. The lining shall be applied to a minimum thickness of 16 mils in not less than two coats.

B. Cement Mortar:
   1. Where specified, pipe and fittings shall be lined with cement mortar as specified in AWWA C205. Fittings and specials larger than 24 inches, not fabricated from centrifugally lined straight sections, shall require 2-inch by 4-inch by 13-gage self-furring wire mesh reinforcement for hand-applied lining.

C. High Temperature Service Epoxy:
   1. Where specified, steel pipe and fittings shall be epoxy lined with not less than 10 mils of epoxy suitable for temperatures of 225 degrees F. Epoxy lining shall be 3M Scotchkote 306, Porter MCR 65 High Solids Epoxy, or equal. Surfaces shall be prepared in accordance with SSPC-SP 10 Near White Blast Cleaning, and the lining applied as recommended by the manufacturer.

D. Glass Lining:
   1. Where specified, pipe and fittings shall be glass lined with a dual layer coating system of vitreous material to a minimum thickness of 10 mils. Glass lining shall provide continuous coverage as tested by a low voltage holiday detector with only isolated voids permitted due to casting anomalies. Voids, other than isolated pinholes, shall be cause for rejection.

2. Pipe and fittings shall have all internal welds ground smooth and any voids or slag holes ground out, rewelded and ground smooth.
3. Glass lining shall be Ferrock MEH-32, Vitco SG-14, or equal.

2.06 PIPE COATING

A. Epoxy:
   1. Unless otherwise specified, pipe and fittings shall be coated with a liquid epoxy as specified in AWWA C210 with the following exceptions:
      a. No coal tar products shall be incorporated in the liquid epoxy.
      b. The curing agent may be an amidoamine as well as the other curing agents listed in AWWA C210.
   2. The coating shall be applied to a minimum thickness of 16 mils in not less than two coats.

B. Polyethylene Tape:
   1. Where specified, pipe and fittings shall be coated and wrapped with prefabricated multilayer cold applied polyethylene tape coating in accordance with AWWA C214. The coating application shall be a continuous step operation in conformance with AWWA C214, Section 3. The total coating thickness shall be not less than 50 mils for pipe 24 inches and smaller and not less than 80 mils for pipe 26 inches and larger.

2.07 FUSION EPOXY COATING AND LINING

A. Where specified, steel pipe and fittings shall be fusion epoxy coated and lined. The fusion epoxy coating shall be 3M Scotchkote 203, or equal. Surface preparation shall be in accordance with SSPC-SP 10 Near White Blast Cleaning. The application method shall be by the fluidized bed method and shall attain 12 mils minimum dry film thickness.

B. Field welds, connections and otherwise damaged areas shall be coated and patched according to the manufacturer's instructions with 3M Scotchkote 306.

2.08 JOINT GASKETS

A. Joint gaskets shall be as specified in Section 40 05 06.13.

2.09 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Affidavits of Compliance with AWWA C200, ASTM A53, or ASTM A106 as applicable.
   2. Contractor's layout drawings as specified in Section 40 05 01-2.04.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206 and Section 40 05 06.16.

2. Sleeve-type mechanical pipe couplings shall be provided in accordance with AWWA M11 and Section 40 05 06.16-2.02 Sleeve-Type Couplings.
3. Pipe lining and coatings at field joints shall be applied as specified in paragraphs 2.05 and 2.06.
4. Unless otherwise specified, buried mechanical couplings and valves shall be field coated as specified in Section 40 05 06.16-2.06.

B. Anchorage:
1. Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01 33 00.

3.02 TESTING

A. Hydrostatic testing shall be in accordance with Section 4 of AWWA C600 except that test pressures and allowable leakage shall be as listed in Section 40 05 01.

END OF SECTION

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SECTION 40 05 31

THERMOPLASTIC PROCESS PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies polyvinylchloride, chlorinated polyvinylchloride, polyethylene, and polypropylene pipe and fittings.

B. Pipe Designations:

1. For use in the Piping System Specification Sheets (PIPESPEC) in Section 40 05 01 and in this section, the following plastic pipe designations are defined:

Designation	Definition
PVC	Polyvinylchloride
CPVC	Chlorinated polyvinylchloride
PE	Polyethylene
PP	Polypropylene

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80

Reference	Title
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2657	Heat-Joining Polyolefin Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings

PART 2 PRODUCTS

2.01 PVC PIPE

A. Pressure Pipe:

1. PVC material for pipe and fittings shall conform to ASTM D1784, Class 12454-B. Pipe and fittings shall either be in accordance with ASTM D1785 or shall conform to ASTM D2241 for standard dimension ratios: 160 psi pipe–SDR 26; 200 psi pipe–SDR 21; 250 psi–SDR 17. Pressure rating for pipe shall be in excess of test pressure specified in Section 40 05 01. Neoprene gaskets with push-on joints shall conform to ASTM F477.
2. Schedule 80 PVC socket type fittings shall conform to ASTM D2467. Schedule 40 PVC fittings shall conform to ASTM D2466. PVC solvent weld cement for socket connections shall meet the requirements of ASTM D2564. Schedule 80 PVC threaded fittings shall conform to ASTM D2464. Fittings for gasketed pipe shall be ductile iron or steel push-on IPS-sized pressure fittings rated for use with the specified class of PVC pipe. Unless otherwise specified, fittings shall be lined and coated in accordance with Section 40 05 24 or Section 33 05 31 as applicable.

B. Nonpressure Pipe:

1. Gravity Sewer Pipe: PVC material for sewer pipe and fittings shall conform to Class 12454-B, as defined in ASTM D1784. Pipe and fittings shall meet the requirements of ASTM D3034 for SDR 35. Neoprene gaskets with push-on joints shall conform to ASTM F477.
2. DRAIN, Waste and Vent Pipe: PVC material for drain waste and vent (DWV) pipe and fittings shall conform to Class 12454-B, ASTM D1784. Pipe and fittings shall conform to ASTM D2665. Unless otherwise specified, connections shall be solvent weld. Connections to traps, closet flanges, and nonplastic pipe shall be with approved adapter type fittings designed for intended use. Solvent weld cement for socket connections shall meet requirements of ASTM D2564.

2.02 CPVC PIPE

A. CPVC material for pipe and fittings shall conform to ASTM D1784, Class 23447-B. Pipe and fittings shall be in accordance with ASTM F441. Neoprene gaskets with push-on joints shall conform to ASTM F477.

B. Schedule 80 CPVC socket type fittings shall conform to ASTM F439. Schedule 40 CPVC socket type fittings shall conform to ASTM F438. CPVC solvent weld cement for socket connections shall meet the requirements of ASTM F493. Schedule 80 CPVC threaded type fittings shall conform to ASTM F437.

2.03 PE PIPE

A. PE pipe shall meet the requirements of ASTM D1248, Type III, Grade P 34, Class C, 100 psi or as specified in Section 40 05 01, whichever is higher. Fittings shall be of the same material, molded socket fusion for sizes 4 inch diameter and smaller and molded or fabricated butt fusion for sizes 6 inch and larger. Fittings shall be 125 psi or as specified in Section 40 05 01, whichever is higher. Heat fusion welding shall be in conformance with ASTM D2657.

2.04 PP PIPE

A. Pressure Pipe:
   1. PP pipe and fittings shall be formulated of polypropylene conforming to ASTM D4101, SDR 11, butt fusion type. Pipe shall be 150 psi rated in all sizes. Heat fusion welding shall be in conformance with manufacturer's recommendation.

B. Drain, Waste and Vent Pipe:
   1. PP drain, waste and vent (DWV) pipe and fittings shall be made from flame retardant, Schedule 40, polypropylene (PPFR) plastic as defined in ASTM D4101. Pipe and fittings used for buried piping and in concealed locations shall be joined by electrical fusion coils energized by a variable low-voltage power supply to completely fuse the interface between the pipe and socket and form a completely homogenous structure. Unless otherwise specified, mechanical joint fittings may be used under bench or in exposed locations where future disassembly is desired. The mechanical method shall be in conformance with the manufacturer's recommendation.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's certificates of compliance with the specified standards and Contractor's layout drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. PVC pipe 3 inches in diameter and smaller shall be joined by means of socket fittings and solvent welding in conformance with ASTM F402. Solvent-cemented joints shall be made in strict compliance with the manufacturer's/supplier's instructions and recommended procedures. Unless otherwise specified, PVC pipe 4 inches in diameter and greater shall be joined by means of gasketed push-on joints and steel or ductile iron push-on or mechanical joint fittings. Fittings shall be lined and coated as specified in Section 40 05 24 or Section 33 05 32. Unless otherwise specified, PVC and CPVC piping exposed to sunlight shall be painted with coating system L-2 as specified in Section 09 90 00.

B. Connections to different types of pipe shall be by means of flanges, specified adapters or transition fittings. Where sleeve type couplings are used, both shall be uniformly torqued in accordance with pipe manufacturer's recommendation. Foreign material shall be removed from the pipe interior prior to assembly.

C. Unless otherwise specified, PE pipe and fittings 4 inch diameter and smaller shall be joined by means of thermal socket fusion and pipe 6 inch and larger by thermal butt fusion. Butt-fusion joining of the pipes and fittings shall be performed with special joining equipment in accordance with procedures recommended by pipe manufacturer. Tensile strength at yield of butt-fusion joints shall not be less than pipe. Flanged adapters shall be provided for connection to valves and where specified.

3.02 TESTING

A. Testing of plastic piping shall be as specified in Section 40 05 01.

END OF SECTION

SECTION 40 05 31.17

PVC GRAVITY SEWER PIPE AND DWV (DRAIN, WASTE, AND VENT) PIPE AND FITTINGS

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies Polyvinylchloride (PVC) Gravity Sewer Pipe and DWV (Drain, Waste, and Vent) Pipe. This Section also specifies fittings and joints for Polyvinylchloride (PVC) Gravity Sewer Pipe and DWV (Drain, Waste, and Vent) Pipe.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 66 00 – Product Storage and Handling Requirements
   3. Section 09 90 00 – Painting and Coating Systems
   4. Section 40 05 02 – Piping System Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2321	Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2855	Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F656	Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic
ASTM F679	Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F1970	Special Engineered Fittings, Appurtenances or Valves for use in Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Systems

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. PVC: Polyvinylchloride

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote each deviation with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification section along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Piping layout drawings as specified in Section 40 05 01.
   4. Manufacturer's product data, catalog cuts, typical installation details, and dimensions. Indicate each Piping System Schedule where the product will be used.

1.06 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide PVC piping system materials as specified in Piping System Schedule on the Drawings for the specified Process Service.

2.02 COMPONENTS

A. PVC Solvent Weld Cement:
   1. Pipe and fittings 12-inch diameter and smaller: IPS 711 Weld-on Cement or Approved Equal.
   2. Pipe and fittings greater than 12-inch diameter: IPS 719 Weld-on Cement or Approved Equal.
   3. Heavy bodied, medium setting.
   4. ASTM 2564, 100 percent solvent and PVC resin. No fillers permitted.
   5. Universal plastic pipe solvent is not acceptable.

B. Primer:
   1. Staining solvent conforming to standard ASTM F656.
   2. Manufactured by solvent weld cement manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drain, Waste and Vent Pipe
   1. Join by means of socket fittings and solvent cement welding in conformance with ASTM D2855 and ASTM F402.
   2. Make solvent-cemented joints in compliance with the manufacturer's/supplier's instructions and recommended procedures.
   3. Connections:
      a. Connect to different pipe materials by means of flanges, specified adapters, or transition fittings.
      b. Foreign material to be removed from the pipe interior prior to assembly.
   4. Bedding and Backfill: Blocking under pipe is not permitted.

B. Gravity Sewer Drainage Pipe
   1. Join by means of Push-On Joints with Flexible Elastomeric Seals conforming to ASTM D3212.
   2. Make push-on joints in compliance with the pipe manufacturer’s recommended installation practice.
   3. Connections:
      a. Connect to different pipe materials by means of specified adapters, or transition fittings.
      b. Foreign material to be removed from the pipe interior prior to assembly.
   4. Bedding and Backfill: As specified in ASTM D2321, blocking under pipe is not permitted.

3.02 FIELD QUALITY CONTROL

A. Conduct tests in accordance with Section 40 05 01.

END OF SECTION

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SECTION 40 05 31.19

CHLORINATED POLYVINYLCHLORIDE DOUBLE CONTAINMENT PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies Chlorinated Polyvinylchloride (CPVC) pipe and fittings for double containment piping systems.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 60 00 – Product Requirements
   3. Section 09 90 00 – Painting and Coating Systems
   4. Section 40 05 02 – Piping System Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASME B31.3	Process Piping
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Socket Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2855	Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F656	Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. CPVC: Chlorinated Polyvinylchloride

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote each deviation with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification section along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Piping layout drawings as specified in Section 40 05 01.
   4. Manufacturer's product data, catalog cuts, typical installation details, and dimensions. Indicate each Piping System Schedule where the product will be used.
   5. Double containment piping system manufacturer's experience. Document years of experience manufacturing double containment piping systems.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Double containment pipe system manufacturer must have a minimum of five years' experience producing double containment pipe systems.

1.07 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. IPEX Guardian Centra-Lok system.

2.02 MATERIALS

A. Furnish PVC and CPVC piping system materials as specified in Piping System Schedule on the Drawings for the specified Process Service.

B. Carrier Pipe as specified in Piping System Specification Sheets.

C. Secondary Containment Pipe and Fittings: CPVC Pipe, ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785.

2.03 COMPONENTS

A. Secondary Containment Fittings:
   1. Secondary Containment Fittings manufactured by the double containment pipe system manufacturer.
   2. Molded components. Materials per ASTM D184.

B. Carrier Pipe Support at Fittings:
   1. Match Carrier Pipe materials for Secondary Containment Supports at Fittings.
   2. Designed for field assembly of carrier pipe fittings in secondary containment fittings using self-centering, locking support clips.
   3. Carrier pipe fittings and secondary containment pipe fittings anchored together using support clips.
   4. Support clips consist of male by female, solvent weld, socket fittings with centering legs.
   5. Support clips must permit uninterrupted drainage along the invert of the secondary containment pipe.

C. Carrier Pipe Support Clips:
   1. IPEX Guardian Centra-Guide or approved equal.
   2. Carrier pipe supports to support and center the carrier pipe inside the secondary containment pipe.
   3. Carrier pipe supports must permit uninterrupted drainage along the invert of the secondary containment pipe.
   4. Provide carrier pipe supports at intervals recommended by the double containment system manufacturer.

D. Leak detection:
   1. Provide 24 VDC plastic encapsulated proximity type leak detections sensors consisting of an external clip-on sensor, drip leg, and drain valve with hose connection.
   2. Each sensor removable for periodic testing and provided with LED testing lamp and adjusting potentiometer.
   3. IPEX Guardian Centra-Guard or approved equal.
   4. Leak detection sensors mounted on the exterior of the secondary containment pipe using a saddle mount configuration.
   5. Penetration of the secondary containment pipe is not permitted for leak detection sensor installations.
   6. Install leak detection sensors at leak detection station locations indicated on the Drawings.
   7. Slope pipe system down toward leak detection stations.

8. Provide NEMA 4X FRP control panel with leak detection sensitivity adjustment and 24 VDC SPDT general alarm relay switch for communication with the plant control system.
9. Consolidate leak detection sensors at each cluster of leak detection wells into a single control panel.

E. CPVC Solvent Weld Cement:
1. Pipe and fittings 6-inch diameter and smaller: IPS 724 Weld-on Cement or Approved Equal.
2. Pipe and fittings greater than 6-inch diameter: IPS 729 Weld-on Cement or Approved Equal.
3. Heavy bodied, medium setting.
4. ASTM F493, 100 percent solvent and CPVC resin. No fillers permitted.
5. Universal plastic pipe solvent is not acceptable.
6. Formulated for use with sodium hypochlorite solution and other caustic solutions.

F. PVC Solvent Weld Cement:
1. Pipe and fittings 12-inch diameter and smaller: IPS 711 Weld-on Cement or Approved Equal.
2. Pipe and fittings greater than 12-inch diameter: IPS 719 Weld-on Cement or Approved Equal.
3. Heavy bodied, medium setting.
4. ASTM 2564, 100 percent solvent and PVC resin. No fillers permitted.
5. Universal plastic pipe solvent is not acceptable.

G. Primer:
1. Staining solvent conforming to standard ASTM F656.
2. Manufactured by solvent weld cement manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Solvent Cement Welded PVC and CPVC Pipe:
1. Join by means of socket fittings and solvent cement welding in conformance with ASTM D2855 and ASTM F402.
2. Make solvent-cement welded joints in strict compliance with the manufacturer's/supplier's instructions and recommended procedures.

B. Connections:
1. Connect to different pipe materials by means of flanges, specified adapters, or transition fittings.
2. Foreign material to be removed from the pipe interior prior to assembly.

C. Plastic pipe installation personnel trained to ASME B31.3.

D. Bedding and Backfill: Blocking under pipe is not permitted.

3.02 FIELD QUALITY CONTROL

A. Carrier Pipe Testing: Conduct hydrostatic pressure tests in accordance with Section 40 05 01.

B. Secondary Containment Pipe Testing: Pneumatic Test.
   1. Medium: Instrument Grade Air or Nitrogen.
   2. Test Pressure: 5 psig maximum.
   3. Duration: 2 hours.
   4. Maximum Allowable Pressure Drop: 0.1 psig over 2 hours.
   5. Maintain 10 psig, minimum, in primary containment pipe during testing of secondary containment pipe.
   6. Test Safety: As specified in Section 40 05 01 for Pneumatic Pressure Testing.
   7. Conform to double containment pipe system manufacturer's compressed gas testing procedures.

END OF SECTION

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SECTION 40 05 33.13

HIGH DENSITY POLYETHYLENE PIPE - SOLID WALL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Heat fusible, uniform thickness, solid wall, constant outside diameter, high-density polyethylene (HDPE) pressure pipe, fittings, and appurtenances.
   2. This Section does not specify HDPE pipe with a corrugated, tubular, or structured wall profile.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 31 23 00 – Excavation, Trenching, and Backfill
   2. Section 40 05 01 – Piping Systems
   3. Section 40 05 07 – Pipe Hangers and Supports

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
   1. ANSI/AWWA C906 - Polyethylene (PE) Pressure Pipe and Fittings, 4-inch through 63-inch, for Water Distribution
   2. AWWA M-55 - PE Pipe – Design and Installation
   3. AWWA C901-20 – Polyethylene (PE) Pressure Pipe and Tubing, 3/4 in. (19 mm) through 3 in. (76 mm), for Water Service
   4. ASTM D2321 - Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
   5. ASTM D2513 - Polyethylene Gas Pressure Pipe, Tubing, and Fittings
   6. ASTM D2657 - Heat Joining Polyolefin Pipe and Fittings
   7. ASTM D2774 - Underground Installation of Thermoplastic Pressure Piping
   8. ASTM D3035 – Polyethylene Plastic Pipe Based on Controlled Outside Diameter
   9. ASTM D3261 - Butt Heat Fusion Polyethylene Plastic Fittings for PE Plastic Pipe and Tubing
   10. ASTM D3350 - Polyethylene Plastics Pipe and Fitting Materials
   11. ASTM F1055 - Electrofusion Type Polyethylene Fittings for OD Controlled PE Pipe and Fittings
   12. ASTM F1668 - Construction Procedures for Buried Plastic Pipe
   13. ASTM F2164 - Standard Practice for Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure.

14. ASTM F2206 - Fabricated Fittings of Butt-Fused Polyethylene
15. ASTM F2620 - Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
16. ASTM F714 - Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.
17. PPI TR 31 - Underground Installation of Polyolefin Piping

1.04 SUBMITTALS

A. Procedures: Section 01300

B. Action Submittals:
   1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   2. Qualifications of the certified fusion technician.
   3. Piping layout drawings as specified in Section 40 05 01.
   4. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate each piping system where the product will be used on the submittal.
   5. Pipe Manufacturers' joint assembly procedure.

C. Informational Submittals:
   1. Procedures: Section 01300
   2. Records of each field butt-fusion joint installation, as specified in this specification.
   3. Manufacturer's affidavit affirming that the materials furnished for the project comply with the standard specified in the Piping System Schedule (Section 40 05 02.00 through 40 05 02.99).

1.05 QUALITY ASSURANCE

A. Qualifications: Field welding by butt fusion and/or electrofusion performed by a factory trained and certified fusion technician. Training and/or certification by fusion equipment manufacturer or pipe manufacturer.

B. Certifications: Furnish affidavit (as specified in AWWA C901 and AWWA C906) documenting compliance AWWA C901 and/or AWWA C906, as appropriate for the pipe material specified in the Piping System Schedule.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00

B. Store on clean, level ground to prevent undue scratching or gouging of the pipe. If the pipe must be stacked for storage, stack in accordance with the pipe manufacturer's recommendations.

C. Prevent damage to pipe from dragging over sharp objects or cutting by chokers or lifting equipment while handling pipe.

D. Handle pipe in accordance with pipe manufacturer's recommendations.

E. Pipe with gouges, cuts, or scratches deeper than 10% of the pipe wall thickness will be rejected.

F. Pipe with cuts, gouges, and/or scratches of the pipe interior will be rejected.

G. Store pipe in accordance with pipe manufacturer's recommendations until installation.

H. Store pipe at ambient outdoor temperature.

I. Provide temporary shading.

J. Avoid coverings that will raise pipe temperature over ambient temperature.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards specified in this identified in the Piping System Schedule on the Drawings

B. Pipe Color:
   1. Black
   2. Where specified in the Piping System Schedule on the Drawings, provide co-extruded longitudinal color stripes equally spaced around the circumference of the pipe. Stripe color as specified in the Piping System Schedule.

C. Fittings:
   1. Provide ARC™ sweep bends manufactured by Pipestar International, or approved equal, for 2-inch through 14-inch long radius bends. Bend radius 3 times the nominal pipe size, measured to the centerline of the bend.
   2. Increase wall thickness to next nominal pressure rating (next lower SDR) for mitered bends and fabricated fittings. 2 miter segments, minimum for deflections of 45 degrees or less. 4 miter segments, minimum for deflections greater than 45 degrees.

D. Flange Ends:
   1. HDPE stub end flange adapter and back up ring.
   2. Furnish beveled flange adapters for disk clearance on flanged connections to butterfly valves.
   3. Furnish stub end flange adapters with radius or chamfered outer diameter transition from pipe wall to stub end.
   4. Chamfer or radius flange ring bore to match transition on stub end flange adapter.
   5. Ductile iron back up rings encapsulated in polypropylene or CF8 (304) Stainless Steel back up rings: Improved Piping products – PPDI, Improved Piping Products - SS-SDR, or approved equal.

E. Couplings:
   1. HGRV – HDPE Groove Coupling

a. HGRV couplings consist of two coupling halves and gasket. Designed to join double-grooved HDPE pipe ends.
b. HGRV (HDPE Grooved Coupling): Victaulic Style 908 or Approved Equal.

2. HPEG – HDPE Plain End with Gripping Teeth
   a. HPEG couplings consist of two coupling halves, gasket, and gripping teeth that engage and grip the exterior of plain end HDPE pipe segments.
   b. HPEG (HDPE Plain End with Gripping Teeth): Victaulic Style 995N, Victaulic Style 905, or Approved Equal.
3. HXGT – HDPE by Grooved End Transition
   a. HDPE by Grooved End Transitions consist of a carbon steel grooved end pressed onto a plain end HDPE pipe stub. Join HDPE by Grooved End Transitions with Flexible Grooved End Coupling.
   b. Carbon steel grooved end transition furnished with cut grooves and fitted with multiple rows of integral circumferential barbs on the inside diameter.
   c. Coat carbon steel components with NSF 61 compliant epoxy prior to pressing onto HDPE pipe.
   d. HDPE by Grooved End Transition: Poly-Cam Series 701 or Approved Equal.
   e. Flexible Grooved End Couplings: Victaulic Style 77, Anvil Gruvlok Figure 7001 or Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION, BURIED

A. Install piping system in accordance with ASTM D2321, AWWA C901 or AWWA C906 and the pipe manufacturer's recommendations.

B. Joining:
   1. Join pipes and fittings above grade, out of the trench.
   2. Butt fusion welds in accordance with the pipe manufacturer's recommendations and ASTM D2657
   3. Obtain optimum fusion parameters from the pipe manufacturer, with regard to fusion temperature, interface pressure, and cooling time.
   4. Follow the manufacturer's recommendations with regard to the optimum fusion parameters, and use proper equipment for the fusion process.
   5. Provide record of each butt fusion joint using McElroy Datalogger, or equal. Record date, time, joint number, operator identification, fusion machine make and model, pipe size and SDR, interfacial pressure during fusion and cooling, and fusion temperature.
   6. Butt fusion joint strength exceeds tensile strength of pipe.
   7. Extrusion welding and hot gas welding is not permitted.
   8. Pipe joints completed by factory trained and certified fusion technicians.
   9. Provide flange joints for connections to different pipe materials, equipment, valves, and other appurtenances unless otherwise specified on the Drawings.
   10. Install electrofusion welds where required for closures and joining HDPE to fixed/installed HDPE pipe or where specified on the drawings. Electrofusion welds installed in accordance with manufacturer's instructions and ASTM F1055.

C. Trench Excavation: per Section 31 21 33.

D. Location and Alignment: Place pipe and fittings in the trench with the invert conforming to the elevations, slopes, and alignments specified on the Drawings.

E. Bedding and Backfill:
   1. Bedding and backfill per Section 31 23 00 and as specified on the Drawings.
   2. Place materials by methods that will not disturb or damage the pipe.
   3. Adjust temperature of HDPE pipe to the temperature of the surrounding soil at the time it is backfilled and compacted.
   4. Work in and tamp the bedding material in the area under the pipe and up to the spring line before placing and compacting the remainder of the embedment.
   5. Blocking under the pipe is not permitted.
   6. Place sufficient backfill to prevent damage, excessive deflections, or other disturbances of the pipe before using heavy compaction or construction equipment directly over the pipe.
   7. Control flotation of pipe when backfilling with flowable materials. Provide sufficient pipe weight, anchor blocks, fill with water, or backfill in lifts.

3.02 INSTALLATION, EXPOSED AND SUBMERGED

A. Install piping system in accordance with Chapter 8 of the Plastic Pipe Institute *PE Handbook*, ASTM F2620, AWWA C901 or AWWA C906, and the manufacturer's recommendations.

B. Joining:
   1. Butt fusion welds in accordance with the pipe manufacturer's recommendations and ASTM D2657
   2. Obtain optimum fusion parameters from the pipe manufacturer, with regard to fusion temperature, interface pressure, and cooling time.
   3. Follow the manufacturer's recommendations with regard to the optimum fusion parameters, and use proper equipment for the fusion process
   4. Butt fusion joint strength exceeds tensile strength of pipe.
   5. Extrusion welding and hot gas welding is not permitted.
   6. Pipe joints completed by factory trained and certified fusion technicians.
   7. Provide flange joints for connections to different pipe materials, equipment, valves, and other appurtenances unless otherwise specified on the Drawings.
   8. Install electrofusion welds where required for closures and joining HDPE to fixed/installed HDPE pipe or where specified on the drawings. Install electrofusion welds per the manufacturer's instructions and ASTM-F1055.

C. Pipe Support:
   1. Conform to Section 40 05 07.
   2. Accommodate thermal expansion and contraction movement.
   3. Support pipe at intervals of 8 feet or less.
   4. Provide pipe cradles supporting the bottom 120 degrees of pipe circumference.

5. Cradle length (measured parallel to pipe axis) not less than half of the pipe's outside diameter.
6. Edges of pipe cradles rounded or rolled to prevent cutting or gouging pipe.

3.03 SYSTEMS START UP

A. Procedures: Section 01 45 20

B. Pressure Testing:
   1. Pressure test pipe per Section 40 05 01.
   2. Install pipe supports, anchors, seismic bracing, and flexibility provisions prior to pressure testing.
   3. Perform pressure testing prior to encasement in concrete or backfilling buried pipe.
   4. Retest following repair of leaks.
   5. Apply initial pressure without makeup pressure for 1-2 hours to allow for diametric expansion or pipe stretching to stabilize.
   6. After the equilibrium period, restore the test section to the test pressure.
   7. Makeup water quantities during the pressure test per the Plastic Pipe Institute Technical Report TR 31-88. No visual leaks or pressure drops permitted during the final test period.

C. Deflection Testing for Buried Pipe:
   1. Perform deflection testing for the entire length of buried pipe.
   2. Deflection testing performed not less than 30 days after completion of any work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads.
   3. Maximum permissible pipe deflection: 4.0 percent of the average inside diameter of the pipe.
   4. Deflection testing device capable of detecting pipe internal dimensions to within 1 percent of the average internal diameter of the specified pipe dimensions.
   5. Remove, replace, and retest pipe sections that fail the deflection testing.

END OF SECTION

SECTION 40 05 45

PIPING SYSTEM IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the supply and installation of permanent identification labels and markers for piping systems.

B. Requirements for the supply and installation of permanent identification tags for valves are specified in Section 40 05 60.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 45 00 – Area Exposure Designations
   3. Section 40 05 02 – Piping System Schedules
   4. Section 40 05 60 – Valves

1.03 REFERENCES

A. References:
   1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ASME A13.1	Scheme for the Identification of Piping Systems
ANSI Z535.1	Safety Colors/APWA Uniform Color Code for Marking Underground Utilities

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Embedded/Encased piping: Piping enveloped in concrete, typically under structures or under roadways.

2. Exposed: All area exposures specified in Section 01 45 00 other than buried, submerged, or encased/embedded.
3. Buried: Below grade walls or roofs; locations covered and in contact with earth/soil.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Provide a full line product brochure showing available Piping System Marker and Detectable Warning Tape standard text and color options. Submit all text and colors proposed for use.
   3. Provide manufacturer's recommended installation instructions for Detectable Warning Tape.
   4. Provide product brochures and data sheets for tracer wire and splice kits. Submit all wire insulation colors proposed for use.
   5. Submit proposed tracer wire access box(es) for test leads. Submit electrical continuity test results upon completion.
   6. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Electrical continuity test results.
   3. Sample of each piping identification plastic marker used.
   4. Sample of each detectable warning tape used.

PART 2 PRODUCTS

2.01 PIPING SYSTEM MARKERS FOR EXPOSED PIPE

A. Identify material contained in exposed piping systems using a colored plastic marker legend system conforming to ASME A13.1.

B. For exposed piping, provide pre-coiled mechanically attached type colored markers that are easily removable. Adhesive type markers are not acceptable.
   1. Resistant to petroleum based oils and grease and meet criteria for humidity, solar radiation, rain, salt, fog, leakage and fungus specified by MIL-STD-810.
   2. Withstand a continuous operating temperature range of -40 to 250 degrees.
   3. Manufactured and applied in one continuous length of plastic including directional arrows. Markers comprised of letters and directional arrows individually applied to the maker are not acceptable. Legends and arrows printed on polyester subsurface and over laminated with Tedlar.
   4. Text size per ASME A13.1.
   5. Marking Services Style MS-995, Brady Style B-689, or approved equal.

C. Each piping system marker to be color coded for identification and labelled with the Process Service Identifier and directional flow arrows indicating the direction of flow in the pipe. Piping System marker background colors are specified in Section 40 05 02 for each process service. Except for piping system markers with an orange, yellow or white background color, provide white text and directional arrows for all piping system markers. Provide black text and directional arrows for pipe markers with an orange, yellow or white background.

2.02 DETECTABLE WARNING TAPE AND TRACER WIRE FOR BURIED PIPE

A. Provide Detectable Warning Tape for all buried piping:
   1. Detectable Warning Tape shall be 6 inches wide, colored per ANSI Z535.1 (APWA Uniform Color Code for Marking Underground Utilities) and made of inert plastic material suitable for direct burial with solid aluminum foil core. Minimum 5 mil laminate thickness. Tin or nickel plated clips for joining sections of tape, as provided by the tape manufacturer.
   2. Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or approved equal.
   3. Print two messages on buried Detectable Warning Tape. The first message reads **"CAUTION CAUTION CAUTION _____ PIPE BURIED BELOW"** with bold letters approximately 2 inches high. Fill the blank with the Process Service name. The second message reads **"CALL____"** with letters approximately 3/4 inch high. Both messages printed at maximum intervals of 2 feet. Fill the blank with phone number provided by the Construction Manager.

B. Install tracer (locate) wire along the buried portion of pipe alignments for the following piping services: [Edit as required for the project. Examples: LSG, CD, ML, NG, POL]
   1. Direct burial rated, 12 gauge solid copper, 600-volt UF tracer wire with heavy-duty PVC insulation. Tracer wire insulation color-coded to match each utility service as designated in ANSI Z535.1 (APWA Uniform Color Code for Marking Underground Utilities).
   2. SPLICES: Silicone-filled UL-Listed product specifically designed for waterproof direct bury splicing of tracer wire. 3M DBR-6; or approve equal.
   3. WIRE ACCESS BOXES: Cast iron valve box top piece frame and cover set within a concrete ring cast flush with grade, as appropriate for the location in which it will be installed and for the traffic loading it may be subject to, and in accordance with the applicable elements of the Standard Detail for valve box installations. Mark lids in raised or recessed lettering with the word “Test”. Submit all wire access boxes proposed for use to the Construction Manager for review.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM MARKERS

A. Provide piping system markers and direction arrows at locations conforming to ASME A13.1 and at the following locations:
   1. Apply intermittent markings on straight pipe runs, close to all valves, fittings, and adjacent to all changes in direction.
   2. Where pipes pass through walls, partitions, and floors, apply markings on both sides of walls, partitions, and floors.
   3. At point of entry and leaving each pipe chase and/or confined space, and piping accessible at each access opening.

4. Adjacent to valves and where valves are in series at intervals of no more than 6 feet.
5. At least once in each room and at maximum spacing of 40 feet. Exception: gas piping to be identified at 6-ft intervals in ceiling plenums.
6. Spacing for markings not less than 1 foot.
7. At the beginning and end points of each run; and, at each piece of equipment in each run.

B. Visibility
1. Place identification on the bottom of the piping system for pipe systems located near ceiling or above the normal line of sight.
2. Place identification on the side of the piping systems for pipe systems located at the normal line of sight or below.
3. Place identification at approximate line of sight for vertical pipe systems.

3.02 INSTALLATION OF DETECTABLE WARNING TAPE

A. Install a continuous ribbon of Detectable Warning Tape as specified for ALL buried piping.

B. Multiple pipes less than 4 inches in diameter installed in a common trench may be provided with a single ribbon of tape per trench. If the total width of such utilities within the common trench exceeds 3 feet, provide two parallel ribbons of tape spaced equally.

C. Provide a separate detectable warning tape for each pipe that is 4 inches or greater in size.

D. Install the tape in accordance with manufacturer recommendations.

E. At end-to-end and branch connections, provide electrical continuity connectors for detectable tape to mechanically and electrically connect ends together as recommended by the manufacturer.

F. Provide a single line of tape 2.5 feet above the centerline of buried pipe. For pipelines buried 8 feet or greater below finished grade, provide a second line of tape 12 inches below finished grade, above and parallel to each buried pipe. Spread tape flat with message side up before backfilling.

3.03 INSTALLATION OF TRACER WIRE

A. Tracer wire shall be a continuous, fully functioning, and tested system to include all appurtenances including splices and wire access boxes at grade.

B. Tracer wire laid along the top of the pipe prior to backfilling. Secure in place with tape every 20 feet. Where the pipe is encased or provided with concrete collars or cut-off walls, lay the wire on top of the encasement (do not encase the wire). Do not pull the wire taut; leave sufficient slack to allow for pipe movement and future repairs.

C. Splice tracer wire using the specified silicone-filled splice kits in accordance with manufacturer recommendations. Ensure the silicone fully encapsulates un-insulated wire ends and are made watertight.

D. Pull tracer wire up into all valve boxes, cleanout access boxes, and into all utility cabinets and meter boxes installed on the pipeline. For each wire end, provide an 18-inch long length of extra wire (coiled and tucked out of the way in an accessible location) for connection to utility locating equipment.

E. Where the pipeline enters structures, vaults, tanks, or buildings, provide a wire access box at grade adjacent to the structure or building for termination of the tracer wire. Provide an 18-inch long length of extra wire (coiled and tucked into the box) for connection to utility locating equipment. Also provide boxes at each pipeline branch, cross or tee, and at intermediate spacing along the pipeline not to exceed 1,000 feet (except where pipeline valves with valve boxes provide the required wire access at those locations and intervals).

F. Upon completion and backfill of the pipeline, test and demonstrate electrical continuity of each segment of tracer wire. Submit test results to the Owner indicating the location of the tested segment. Use conductive testing method; inductive test methods are not acceptable. Repair all faulty work at no additional cost to the Owner until the system is functional and approved.

3.04 FIELD QUALITY CONTROL

A. Comply with manufacturer's handling and installation instructions.

B. Provide continuity testing of tracer wire as specified herein.

END OF SECTION

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SECTION 40 05 57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies manual operators for valves and gates, and operator appurtenances.

1.02 REFERENCES

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA C500	Gate Valves 3 through 48 inch NPS, for Water and Sewage Systems

PART 2 PRODUCTS

2.01 GENERAL

A. Except as specified in valve and gate specification sections, manual operators shall be as specified herein. Operators shall be mounted on the valve or gate and provided as a unit. Each valve body or operator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

2.02 OPERATORS

A. General:
   1. Manual operators shall have operating torques less than 80 foot-pounds. Unless specified otherwise, each manual operator shall be provided with an operating wheel. Unless specified otherwise, the direction of rotation of the operator shall be counterclockwise for opening.

B. Wrench Nuts:
   1. Wrench nuts shall comply with Section 3.15 of AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of the wrench nut operated valves.

C. Chain Wheels:
   1. Chain wheels shall be ductile iron. Operating chains shall be galvanized.

2.03 OPERATOR APPURTENANCES

A. Valve Boxes:
   1. Valve boxes shall be cast iron and shall have suitable base castings to fit properly over the bonnets of their respective valves and heavy top sections with stay-put covers. Covers shall be hot-dip galvanized.

B. Floor Boxes:
   1. Floor boxes shall be hot-dip galvanized. Where the operating nut is in the concrete slab, the floor box shall be bronze bushed. Where the operating nut is below slab, the opening in the bottom of the box shall be sufficient for passage of the operating key.

C. Adjustable Shaft Valve Boxes:
   1. Adjustable shaft valve boxes shall be concrete or cast iron Brooks No. 3RT, Christie G5, Empire 7-1/2 valve extension box, or equal. Box covers on water lines shall be impressed with the letter "W." Gas line covers shall be impressed with the letter "G."

2.04 PRODUCT DATA

A. Manufacturer's catalog information and other data confirming conformance to design and material requirements shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 GENERAL

A. Installation shall be as specified herein. Valve operators shall be located so that they are readily accessible for operation and maintenance. Valve operators shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Valve operators shall not be mounted where shock or vibration will impair their operation. Support systems shall not be attached to handrails, process piping, or mechanical equipment.

3.02 OPERATORS

A. General:
   1. Valves and gates shall be provided with manual operators, unless specified otherwise. Where possible, manual operators shall be located between 48 inches and 60 inches above the floor or a permanent work platform.

B. Wrench Nuts:

1. Wrench nuts shall be provided on buried valves, on valves which are to be operated through floor boxes, and where specified. Extended wrench nuts shall be provided if necessary so that the nut will be within 6 inches of the valve box cover.

C. Chain Wheels:

1. Unless otherwise specified, valves with centerlines more than 7 feet, 6 inches above the specified operating level shall be provided with chain wheels and operating chains. Chain wheel operated valves shall be provided with a chain guide. Operating chains shall be looped to extend within 4 feet of the specified operating level below the valve. For plug-type valves 8 inches and larger, the operator shall be provided with a hammer blow wheel. Hooks shall be provided for chain storage where the chain may hang in a walkway.

3.03 OPERATOR APPURTENANCES

A. Valve Boxes:

1. Valve boxes extending to finished surfaces shall be provided for buried valves.

B. Floor Boxes:

1. Floor boxes shall be provided for wrench operation of valves located below concrete slabs. Each floor box and cover shall be of the depth required for installation in the slab.

END OF SECTION

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SECTION 40 05 57.23

POWERED ACTUATORS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies powered actuators for valves and gates and actuator appurtenances.

B. Types:
   1. For use in the control valve schedule in Section 40 06 20.13 and in this section, powered actuators are defined as follows:

Actuator Type (ACTUSPEC)	Service	Definition
EMTT	Throttling (Modulating)	Electric motor multi-turn
EQTT	Throttling (Modulating)	Electric motor quarter-turn
EMTI	Isolating (Open-Close)	Electric motor multi-turn
EQTI	Isolating (Open-Close)	Electric motor quarter-turn
PDT	Throttling (Modulating)	Pneumatic diaphragm
PDI	Isolating (Open-Close)	Pneumatic diaphragm
PCT	Throttling (Modulating)	Pneumatic cylinder
PCI	Isolating (Open-Close)	Pneumatic cylinder

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A519	Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM B584	Copper Alloy Sand Castings for General Applications

Reference	Title
JIC P-1	Pneumatic Standards for Industrial Equipment and General Purpose Machine Tools
NEMA ICS-2	Industrial Control Devices, Controllers and Assemblies

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Manufacturer's catalog information and other data confirming conformance to design and material requirements.
4. Application sheets and schedules for each valve and actuator showing required mounting, operating torque for valve, torque capacity of actuator, and power or air pressure requirements. Valve identification (tag) number shall be clear for each application.
5. List of components being provided for each valve, actuator and positioner.

PART 2 PRODUCTS

2.01 GENERAL

A. Actuators shall be factory-mounted on the valve or gate and provided as a unit. Each valve body or actuator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

2.02 POWERED ACTUATORS

A. General:

1. Actuators shall be sized to produce an operating torque equal to twice the maximum required valve operating torque under the specified flow conditions. Specific requirements for each type powered actuator are specified on the actuator specification sheets in paragraph 3.04.

B. Electric Actuators

1. General: Unless otherwise specified, electric actuators shall be provided in accordance with the actuator specification sheets and the following requirements.
2. Motor: Actuator motors shall be heavy duty, specifically designed for valve or gate actuator service. Motors shall be of totally-enclosed, non-ventilated construction. Motor shall have an internal space heater with nominal rating of 25-watts. Motors shall be rated as specified in Section 40 06 20.13 and shall be or shall incorporate:
    a. Four-pole 1800 RPM or provide pole-speed as required for the application.
    b. Suitable for use with 460 volt, 3-phase, 60-Hertz power with +/- 10% voltage fluctuation.
    c. NEMA Class F insulation.
    d. Thermistor for thermal protection embedded in the motor windings.
    e. Automatic motor overload relay reset.
    f. Four conduit openings.
3. Enclosure: Motor and electrical enclosures shall be rated for the application and location specified:
    a. NEMA-4 Weatherproof
    b. NEMA-6 Submersible [Rating TBD]
    c. NEMA-7 Explosion proof
4. Motor Starter: Actuator shall be provided with a three phase full voltage reversing starter rated at 30-amperes both mechanically and electrically interlocked with overload protection or elements in each of the three poles.
    a. Control Transformer shall be epoxy encapsulated and impregnated and rated at a minimum of 75VA with 120Vac secondary and other required secondary voltages of 18 Vac and 12 Vac as required, with short-circuit and overload protection.
    b. Provide lockable internal circuit breaker or internal disconnect switch where possible.
5. Disconnect Switch: Actuator shall be provided with a lockable, heavy-duty, nonfused-disconnect switch that is close-coupled to the motor actuator.

6. Gearing: Gearing shall be double-reduction, with a helical gear and pinion forming the first reduction and a worm and worm gear forming the second. The helical gear and pinion shall be fabricated from heat-treated alloy steel with hobbed and finished shaved teeth. The worm shall be fabricated from heat-treated alloy steel, ground, carburized and hardened. The worm gear shall be fabricated from high tensile strength bronze with hobbed teeth.
    a. The stem nut shall be fabricated from high tensile strength bronze and shall be the two-piece type, when possible. It shall be possible to remove the stem nut from rising stem actuators from the top without removing the actuator from the valve or gate, disconnecting any electrical wiring, or disassembling any of the gearing. All gearing shall be designed to withstand a 100 percent overload.
7. Torque Switch: Electric actuators shall be provided with a double-torque switch set to disengage motor power at 75 percent of the shaft's design torque. The torque switch shall operate in both the opening and closing directions and shall operate during the complete cycle without the use of auxiliary relays, linkages, latches, or other devices.
    a. Each side of the torque switch shall have a numbered dial for set point adjustment. A calibration tag shall be mounted near each switch for correlating the dial settings with output torque.
8. Manual Actuator: Electric actuators shall be provided with a handwheel for manual operation. The handwheel shall not rotate during motor operation nor shall a locked motor prevent manual operation. Motor or manual selection shall be accomplished by a positive declutching knob or lever which will disengage the motor and motor gearing mechanically but not electrically. Prohibit manual and motor simultaneously operation. Hand operation shall not require more than 100 pounds of rim effort at maximum torque.
9. Hammer Blow Device: Electric actuators shall be provided with a built-in lost-motion device that allows sufficient travel of the worm gear, prior to engaging the stem nut, for the motor to reach full speed. This action shall impart a "hammer blow" to start the valve or gate in motion in either direction. The load shall be shared equally by two lugs cast integrally on the drive sleeve.
10. Conduit Openings: Electric actuators shall be provided with the largest available: power conduit opening; control conduit opening; and instrument conduit opening.

C. Pneumatic Diaphragm Actuators:
1. General: Unless otherwise specified, pneumatic diaphragm actuators shall be provided in accordance with the actuator specification sheets and the following requirements.
2. Body And Cylinder. Cylinder size shall be sufficient to produce the torque specified in paragraph 2.02 General, with a supply air pressure of not more than 65 psig.
3. Body And Diaphragm: Actuators shall be provided with a pressed steel diaphragm casing and a cast-iron spring barrel and housing. Diaphragm shall be polyester reinforced nitrile rubber. Diaphragm size shall be sufficient to produce the torque specified in paragraph 2.02 General, with a supply air pressure of not more than 40 psig.

4. Manual Handwheel Actuator: Actuators shall be provided with a manual worm gear, handwheel actuator. Unless otherwise specified, the actuator shall have a 90-degree rotation, and shall be equipped with travel stops capable of limiting the valve closing to any angle between 0 and 30 degrees and the valve opening to any angle between 60 and 90 degrees.
    a. The actuator body shall be cast iron with a steel cover. The worm shall be steel, and the worm gear shall be cast iron. The worm gear shaft and handwheel shaft shall be Type 630 stainless steel. The handwheel shall be 12 inches in diameter and shall be cast iron. It shall be possible to mount the actuator in various positions relative to the pipeline. It shall be possible to mechanically disengage the manual actuator from the valve shaft when not in use; no tools shall be required to accomplish this operation. The manual actuator shall be Fisher Controls, Type 1078, or equal.

D. Pneumatic Cylinder Actuators:
1. General: Unless otherwise specified, pneumatic cylinder actuators shall be provided in accordance with the actuator specification sheets and the following requirements.
2. Mechanism: Actuators shall be double-acting unless otherwise specified in Section 40 06 20.13. Actuators shall be designed so that the spring return option may be added in the field after installation. Unless otherwise specified, actuators shall be double-piston, rack-and-pinion type and shall provide a 90-degree rotation of the output shaft. Actuators shall be totally enclosed, with no external moving parts, except for the output shaft which shall be accessible for manual operation of the valve. Bearing surfaces, including the inside cylinder wall and guides, shall be coated with a permanent, dry-film lubricant and corrosion inhibitor.
    a. Cylinder, end caps, and spring cartridge, shall be made of precision extruded, hard-anodized aluminum. Pistons shall be made of hard-anodized aluminum alloy and the output shaft and pinion shall be hardened and tempered alloy steel. Actuators shall be suitable for operating in temperatures ranging from -20 to +160 degrees F. Piston seals shall be O-ring type. Actuators shall be suitable for use with non-lubricated dry instrument quality air at up to 120 psig. Actuators shall have internal porting with no external piping.
    b. Heavy-duty, totally enclosed scotch-yoke type mechanisms, where specified, shall comply with applicable portions of the specification for double-piston type actuators and shall be suitable for use with non-lubricated dry instrument quality air. Cylinder shall be steel, ASTM A519, Grade 1018; piston shall be gray iron; bearings shall be bronze, ASTM B584, Grade 88-10-2; and seals shall be lip-or cup-type of duro-nitile elastomer. Steel cylinder rod shall be electroplated with nickel.
    c. Scotch-yoke type mechanisms may also be provided when the double-piston type is unable to comply with the requirements of paragraph 2.02 General.
3. Mounting: The actuator output shaft shall attach directly to the valve stem with no intermediate linkages. Actuators shall be suitable for operation in any valve mounting attitude and either parallel or perpendicular to the pipeline.

2.03 ACTUATOR APPURTENANCES

A. Tubing:
1. Unless otherwise specified, tubing furnished with powered actuators shall be in accordance with Section 40 79 00-2.04 Copper Tubing.

B. Tube Fittings:
   1. Unless otherwise specified, tube fittings furnished with powered actuators shall be in accordance with Section 40 79 00-2.04 Plastic Tubing.

C. Air Pressure Filter Regulators:
   1. Filter regulators shall be provided where specified. Filter regulators shall have aluminum bodies and a second tapped output gage connection. Filter regulators shall be provided with an output pressure gage and range spring appropriate for the intended application. The output pressure gage shall be a minimum of 2 inches in diameter and shall have an accuracy of plus or minus 2 percent of scale, or better.
   2. The filter element shall be 40 micron, replaceable and shall be made of resin-impregnated cellulose. The filter dripwell shall be equipped with a drain cock. Filter regulators shall be adjustable over the spring range by means of a wrench-adjustable set screw. The set screw shall be equipped with a lock nut. Filter regulators shall be equipped with an internal relief valve to maintain the output pressure at set point during periods of no flow. Filter regulators shall be Fisher Type 67FR, or equal.

D. Identification Tags:
   1. Each powered actuator shall be provided with a 16-gage stainless steel identification tag that bear the equipment description and tag number of the actuator, as specified. Characters shall be 1/4 inch, die-stamped. Identification tags shall be securely attached to the actuator in a readily visible location using stainless steel screws or wire.

2.04 PRODUCT DATA

A. The following information, and technical data for all equipment specified in this section shall be provided in accordance with Section 01 33 00.
   1. Testing procedures and forms specified in paragraph 3.02 General Requirements.
   2. Training Certification Section 43 05 11-Form B specified in paragraph 3.03.
   3. Operating and maintenance data in conformance with Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Installation shall be as specified herein. Valve actuators shall be located so that they are readily accessible for operation and maintenance and mounted for unobstructed access.
      a. Valve actuator mounting shall not obstruct walkways.
      b. Valve actuator support systems shall not be attached to handrails, process piping, or mechanical equipment.
      c. Valve actuators mounting shall not be located where shock or vibration will impair their operation.

B. Powered Actuators:
   1. General: Powered actuators shall have their manual operating accessory, where possible, located between 48 inches and 60 inches above the floor or a permanent work platform
   2. Identification Tags: Tags shall be located in a clearly visible location on the valves. If necessary, reposition and reattachment with stainless steel screws or wire.
   3. Electrical Power Wiring: Electric power wiring and equipment shall be in compliance with Division 26.
   4. Signal Wiring: Electrical signal wiring and equipment shall be in compliance with Division 26.
   5. Instrument Supply And Signal Air Connections: Instrument supply and signal air connections shall comply with Section 40 79 00.

3.02 TESTING

A. General Requirements:
   1. Testing shall be performed in accordance with Section 01 45 20, and this section. No required test shall be applied without prior notice to the Construction Manager to witness any test. At least 14 days before the commencement of any testing activity, a detailed step-by-step test procedure, complete with forms for the recording of test results shall be provided. All equipment necessary to perform the required tests shall be provided.

B. Piping Testing:
   1. Pneumatic Piping Systems: Pneumatic piping systems shall be tested for leaks in compliance with Section 40 79 00.
   2. Liquid Piping Systems: Liquid piping systems shall be tested for leaks in compliance with Section 40 05 01.

3.03 TRAINING

A. Operation and maintenance training for the equipment provided under this section shall be provided for the Owner's personnel in accordance with Section 01 79 00. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

END OF SECTION

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SECTION 40 05 59.23

FABRICATED SLIDE GATES

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the minimum requirements for corrosion-resistant fabricated slide gates (gates) for control of drinking water as shown on the Drawings and specified herein. Gates shall be all 316L stainless steel construction. The scope of supply shall include gate frames, slides, seals, stems, stem guides, operators, floor stands, gate enclosures where specified, and all other appurtenances, in-place and complete. Powered operators for gates are specified in Section 40 06 20.13.

B. EQUIPMENT LIST: Equipment provided under this section is listed in paragraph 1.04, Service Requirements.

1.02 QUALITY ASSURANCE

A. REFERENCED STANDARDS: This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

Reference	Title
ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM D2000	Standard Classification System for Rubber Products in Automotive Applications
AWWA C561-12	Fabricated Stainless Steel Slide Gates
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

B. UNIT RESPONSIBILITY: Unit responsibility, as specified in Section 43 05 11, is assigned to the gate manufacturer (Manufacturer) for the gates and appurtenances specified in this Section and for the powered operators specified in Section 40 06 20.13.

C. All gates for this project shall be supplied by the same Manufacturer, who shall be fully experienced, reputable and qualified in the manufacturing of the equipment furnished and who has been fabricating gates and appurtenances for a minimum period of 10 years.

1.03 SUBMITTALS

A. PROCEDURES: Section 01 33 00.

B. Product information, calculations, charts, and graphs demonstrating compliance with the requirements of this Section and the Drawings.

C. Plans, elevations, sections, and details showing dimensions and mounting requirements for each gate specified.

D. Manufacturer's data including materials of construction, construction details of equipment, and weight of equipment.

E. Manufacturer's product literature.

F. Electric motor operator data, where applicable, including manufacturer's catalog information, complete dimensional data, drive unit size, calculations substantiating selection and wiring diagrams.

G. Certificate of unit responsibility attesting that unit responsibility has been assigned as specified in this Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

H. Results of factory testing including leak testing per AWWA C-561, Section 5.22.

I. Name, location, and qualifications of the passivation shop.

J. Certification attesting that all gate components have been cleaned, passivated and tested in accordance with the procedures described in this section

K. Manufacturer's operation and maintenance manual defining maintenance requirements.

1.04 SERVICE REQUIREMENTS

A. PERFORMANCE REQUIREMENTS
   1. Gates are intended to isolate channels and pipes or to control water surface elevations.
   2. Gates shall be designed for the Design Head specified. The Design Head is defined as the maximum head that will be applied to the gate. The Design Head is measured from the maximum water surface elevation to the bottom of the gate.
   3. Slides and frames shall have a safety factor of 5 with regard to ultimate tensile, compressive and shear strength; calculations shall be submitted to show conformance.
   4. Gates shall comply with field leakage tests as defined in AWWA C561.
   5. Gates shall not require exercise at a frequency of more than once per year to meet the extended warranty requirements described in this section.
   6. Gates shall be passivated prior to shipping in accordance with the requirements of this section.

B. See the Gate Schedule in drawings for specific dimensional and design requirements.

1.05 COMPONENT SIZING

A. Operating forces used for determining the strength of gate components (yokes, frames, slides, stems, slide nut pockets, and other load-bearing members) shall be based on the sum of the guide friction force (computed using an opening breakaway friction factor of 0.2) and the weight of slide and stem.

B. When the gate is in motion, the operating forces shall be based on the sum of the frictional force (using a guide friction factor of 0.25) and the weight of slide and stem.

1.06 PICKLING AND PASSIVATION OF STAINLESS STEEL

A. PASSIVATION:
   1. Stainless steel surfaces shall be cleaned, physically or chemically descaled, passivated, and tested for presence or absence of free iron in accordance with ASTM A380. The test results shall indicate an absence of free iron. Submit manufacturer's certification that all stainless-steel surfaces have been cleaned, descaled, passivated, and tested in accordance with ASTM A380 and that the surfaces are free from free iron. Equipment that is not certified will not be accepted. Manufacturer shall submit for approval their cleaning, descaling, passivation, and testing procedures to ensure proper cleaning and passivation has occurred.
   2. For purposes of this section, passivation is defined as the removal of exogenous iron or iron compounds from the surface of stainless steel by means of treatment with an acid solution that will remove the surface contamination but will not significantly affect the stainless steel itself.
   3. Equipment components that bolt together shall be disassembled prior to passivation treatment to allow for effective circulation and removal of cleaning solutions.

B. PROTECTION:
   1. All passivated stainless steel shall be protected by applying shrink wrap to all parts of the equipment sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping, and installation. Protected equipment shall be tagged with highly visible warning sights stating the equipment has been passivated and shall only be opened by authorized personnel. Equipment arriving at the project site without proper protection will require retesting for the presence of free iron and re-passivation if free iron is detected.

C. Assembly of equipment following passivation – If assembly of bolted parts is required following passivation, it shall be done at the manufacturing facility under clean conditions such that the parts will not be contaminated with exogenous iron or iron compounds. Following assembly, retest for the presence of free iron per ASTM A967 and treat any contaminated areas with citric acid solution. Equipment requiring assembly shall be re-shrink wrapped sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping and installation.

D. WITNESS OF PASSIVATION PROCESS:
   1. The Owner retains the right to witness the stainless steel passivation process. Provide at least 30-days notice prior to start of passivation process.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Gates shall be all stainless steel construction. Acceptable manufacturers include the following:
   1. Stainless steel slide gate manufacturers:
      a. Whipps, Inc. Athol, Massachusetts
      b. Fontaine International Corporation, Orange Massachusetts
      c. Hydrogate, Denver Colorado
      d. Waterman Industries, Exeter California
      e. Approved equal

B. The manufacturer's standard models or products may require modifications to conform to specified requirements.

2.02 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Slide	ASTM A240 Type 316L stainless steel
Frame	ASTM A276 Type 316L stainless steel
Slide Seats	ASTM D4020 UHMW Polyethylene
Seating faces or seals	ASTM D4020 UHMW PE
Stem and supports	ASTM A276 Type 316 stainless steel
Fasteners, adjusting hardware, and anchors	ASTM A276 Type 316 stainless steel
Yoke	ASTM A276 Type 316L stainless steel
Flush bottom seal	Resilient synthetic rubber bonded to frame or ASTM D2000 neoprene
Pedestal/Torque Tube	ASTM A276 Type 316L stainless steel

2.03 FEATURES

A. GENERAL:
   1. Mounting requirements as shown on the Drawings and specified in this section.
   2. Unless otherwise indicated, provide gates with rising stems with clear, graduated plastic covers in accordance with AWWA C561.
   3. Weir gates having a width greater than 60 inches shall have dual stems mechanically linked to a common operator.
   4. Stainless Steel Passivation: All stainless steel components to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380 and the specific requirements of this section.

B. SLIDE:
   1. Slides shall consist of steel plate reinforced with steel members welded to the plate. Minimum thickness of the steel plate shall be ¼".

2. Slides shall be reinforced with horizontal stiffeners welded to vertical stiffeners. Slides shall not deflect more than 1/16 of an inch or 1/1000 of the span of the gate, which ever is less, under the design head.
3. The slide manufacturer shall submit drawings and comprehensive design criteria to substantiate that the maximum deflection for each slide has not exceeded 1/16 of an inch or 1/1000 of the span, whichever is less, regardless of the type used. Comprehensive safety factor calculations shall include bending moments, buckling stress, and bonding stress with thermal expansion factors. Safety factors shall be calculated for the slide under the maximum head indicated in this section, and for shear at the slide/seal interface.

C. FRAME:
1. Guide frames extending above operating floors or slabs shall be self-contained and sufficiently strong so that no further support or reinforcement is required. Frames for self-contained gates shall be designed for maximum loads imposed by gate operators in the stalled condition plus the weight of the slide, stem, torque tube or pedestal, and operator.
2. The yoke shall be formed by two structural members welded at the top of the guides to provide a one-piece rigid frame and configured to enable slide removal without removing the yoke. The yoke shall be designed to support the maximum stall force applied by the operator in addition to the weight of the stem, torque tube or pedestal, and operator where this equipment is being supported at the yoke.
3. The frame shall be designed with a minimum factor of safety of 4 with regard to ultimate tensile, compressive, and shear strength.
4. Wall-mounted frames shall be the flanged type. Guides for wall mounted frames shall be formed from one plate with wrap around gussets. Bolted together guides are not accepted.
5. Embedded frame gates shall be installed in block-out recesses formed in the channel walls and floor.
6. Thimble-mounted gates shall be drilled to match the wall thimble. Wall thimbles shall conform to AWWA C561.

D. SEALS:
1. Gates shall incorporate factory-set self-adjusting seals utilizing a sealing surface of UHMW PE to achieve the leakage rates specified. Self adjusting seals shall not require adjustment and shall be replaceable without removing the guide frame.
2. All moving contact surfaces shall be incompatible to each other thereby minimizing sticking or jamming.

E. STEMS:
1. All stems shall be of the rising type unless otherwise specified.
2. Provide stem diameter to withstand at least twice the rated output of the electric operator or the manual operator at 40-pounds pull. Stems shall be minimum 1-3/8-inch diameter.
3. Stem guides shall be provided at intervals necessary to maintain a slenderness ratio (L/R) of the unsupported stem length of less than 200, where R is the radius of gyration of the stem.

4. Stems shall be designed to withstand tensile and compressive loads that occur under maximum operating conditions. Design for compressive loading shall meet AWWA C561 standard using Euler's formula where C=2 with a minimum safety Factor of 2 to 1.
5. Stem sections shall be joined together by solid couplings, threaded and keyed to the stems. All couplings of the same size shall be interchangeable.
6. The threaded portion of the stem shall have dual lead, machine rolled, full depth ACME type threading with a 16 micro-inch finish or better. Stub threads are not acceptable.
7. Stems shall be fixed to the slide by a bolted connection or threaded and keyed assembly into a stem block or thrust nut attached to the disc in a stem block pocket, which is welded to the disc.

F. OPERATORS:
1. See Gate Schedule for operator requirements.
2. Unless otherwise indicated, manual operators shall meet requirements of AWWA C561 as appropriate.
3. Yoke-supported operators shall be provided with 316 SS pedestals between the top of the yoke and the operator. See drawings for length requirements.
4. Unless otherwise indicated and whenever possible, operator base shall be set 42" above the walking surface.
5. Manual operators are specified in Section 40 05 57.13.
6. Electric operators are specified in Section 40 05 57.23.

2.04 FACTORY TESTING

A. Conduct shop performance test per AWWA C561. All gates shall be factory leak tested and field leak tested following installation. Submit written report of results.

B. The Owner retains the right to witness the stainless steel preparation and passivation process. Provide at least 30-days notice prior to start of passivation process for gates and appurtenances.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install gates and appurtenances in accordance with manufacturer's instruction and as shown on the Drawings.

B. For embedded gates, fill blockouts along guide frames and gate sill with grout following installation.

C. Provide all 316 SS anchors; size anchors in accordance with the design requirements specified in this section and in accordance with Sections 01 73 24, 05 10 00, and 43 05 11.

D. Proper handling shall incorporate all practices described in Section 8.5 – Protection of Cleaned Surfaces, ASTM A380. Passivated parts contaminated due to improper handling and installation will require retesting for the presence of free iron and re-passivation if free iron is detected.

3.02 FIELD TESTING

A. Operation and Leakage Tests: In accordance with AWWA C563 or AWWA C 561 as appropriate.

B. Leakage rates shall not exceed 0.05 gpm per linear foot of seating perimeter.

C. Provide the following manufacturer's services during startup and testing: 1. Two trips with one day per trip for gate installation inspection with no water in basin. 2. Two trips with one day per trip for gate functional testing and leakage testing with water in the basin.

3.03 TRAINING

A. Provide four hours of training as specified in Section 01 66 00. Training shall be certified on Form 43 05 11-B specified in Section 01 73 24.

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SECTION 40 05 60

VALVES

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the supply, installation and testing of valves. Materials and performance requirements for valves are specified in Detailed Valve Specifications. Detailed Valve Specifications are provided in Sections 40 05 61.01 through 40 05 89.99. Additional Detailed Valve Specifications for some valves used for HVAC service are provided in Division 23.

B. Determining Valve Type:
   1. Drawings specify valve types (gate, plug, butterfly, check, globe, etc.) used in each pipeline. Process fluids that will be conveyed in pipelines are identified by the Process Service Identifiers shown on the Drawings.
   2. Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99) specify piping system materials and components, including valve requirements, based on the Process Service Identifier specified on the Drawings for the pipeline or piping system. Piping System Schedules reference Detailed Valve Specifications that specify requirements for each valve type used in the pipeline or piping system.
   3. Provide valves conforming to the Detailed Valve Specifications listed in the Piping System Schedule for the valve/line size, process service, and valve type specified on the Drawings. Example: The Drawings specify a ball valve on a 1-inch line. The Piping System Schedule for the process service specified on the Drawings refers to Section 40 05 63.01 for 1/2 through 2 1/2 inch ball valves. For this example, provide the subject ball valve per the requirements specified in 40 05 63.01.
      a. Example: The Drawings specify a ball valve on a 1-inch line. The Piping System Schedule for the process service specified on the Drawings refers to Section 40 05 63.01 for 1/2 through 2-1/2-inch ball valves. For this example, provide the subject ball valve per the requirements specified in 40 05 63.01.

C. Section 40 06 20.13 specifies electric, pneumatic, and hydraulic powered control valves, complete with valve, actuator, and other ancillaries.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 58 01 – Identification Systems
   2. Section 01 78 23 – Operation and Maintenance Manual
   3. Section 40 05 02 – Detailed Piping Specification Sheets
   4. Section 40 06 20.13 – Actuated Valve and Gate Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI 16.10	Face-to-Face and End-to-End Dimensions of Valves
ANSI B1.20.1	Pipe Threads, General Purpose
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.34	Valves—Flanged, Threaded, and Welding End
API 607	Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
ASTM A48	Gray Iron Castings
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A216/A216M	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A276	Stainless and Heat Resisting Steel Bars and Shapes
ASTM A351	Castings, Austenitic, for Pressure-Containing Parts
ASTM A516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A536	Ductile Iron Castings
ASTM A571	Austenitic Ductile Iron Castings
ASTM A995/A995M-13	Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
ASTM B124	Copper and Copper Alloy Forging Rod, Bar, and Shapes
ASTM B148	Aluminum-Bronze Sand Castings
ASTM C283	Resistance of Porcelain Enameled Utensils to Boiling Acid
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D5162	Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C507	Standard for Ball Valves

Reference	Title
AWWA C508	Swing Check Valves for Waterworks Service, 2 – 24 Inches NPS
AWWA C517	Resilient-Seated Cast Iron Eccentric Plug Valves
AWWA C550	Protective Interior Coatings for Valves and Hydrants
MSS SP-70	Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-81	Stainless Steel, Bonnetless, Flanged, Knife Gate Valves
MSS SP-110	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
NSF 61	Drinking Water System Components - Health Effects
UL 429	Electrically Operated Valves
UL 1002	Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00
2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal will be sufficient cause for rejection of the entire submittal with no further consideration.
3. Catalog cuts and/or shop drawings for each type of valve indicating the valve type (Detailed Valve Specification Section Number), materials of construction, dimensions, operating torque, valve end connection configuration, pressure rating, and operating temperature range.
   a. For all chemical, toxic, or corrosive service applications, as identified in Section 40 05 02 – Piping System Schedules, a letter or certification that materials of construction are compatible with the designated service fluid.
   b. All pressure rating information and Cv factor data.
4. An amended Detailed Valve Specification for all valve types provided for this contract. Indicate with check marks where the valve supplied meets the requirements specified and with written amendments where the product differs from the specification.
5. Factory Acceptance Test results and/or Certified Statement of Proof-of-Design testing results when specified in Detailed Valve Specifications.
6. Action Submittal Items listed on Detailed Valve Specifications

B. Informational Submittals:

1. Affidavits and registration numbers as specified.
2. Operating and Maintenance data for incorporation in operation and maintenance manual, as specified in Section 01 78 23 and individual specs.

3. Informational Submittal Items listed on Detailed Valve Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Deliver valves to site in accordance with Section 01 66 00 and using loading methods which do not damage any valve components or coatings.

C. Tag loose valves as specified in Section 01 66 00, stating size, type, coatings and mating parts shipped loose or separate.

D. Store on site until ready for incorporation in the work using methods recommended by the manufacturer to prevent damage, undue stresses, or weathering.

1.06 WARRANTY

A. Where a warranty duration is specified by the Detailed Valve Specification, provide a special warranty valid for the specified duration.

B. Where no special warranty requirements are specified in the Detailed Valve Specification, provide manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 VALVE CONFIGURATION REQUIREMENTS

A. General
1. Provide valves of the same type, size range and service from a single manufacturer.
2. Provide new, unused valves for the work.
3. Provide valve materials free from defects or flaws, with true alignment and bores.
4. Provide valves that open by turning the valve shaft to rotate counter-clockwise unless otherwise specified in the Detailed Valve Specification Section.

B. Provide padlockable lockout feature on all valves.

C. Manual Operators
1. Provide valves with manual operators as specified in the Detailed Valve Specification, unless specified otherwise in Section 40 06 20.13.
2. For hand wheels, clearly show the direction of opening in raised lettering and symbols.
3. The maximum rim pull on a hand wheel is not to exceed 65 lb. when one side of the valve is at test pressure and the other side is at atmospheric pressure. Where a shaft mounted hand wheel would require greater force to operate, provide a torque reduction gearbox operator. Unless different operators are scheduled or specified on the Drawings, conform to the following minimum requirements.
4. Provide 6 (total) eight-point operating wrenches for use on all valves with square nut operators.
5. Quarter turn lever operators are to be perpendicular to the pipe runs when the valves are closed.

6. Provide butterfly valves with 10 position latching levers except where used to balance air flows. Where used to balance air flows provide infinite position, screw down levers.
7. The maximum pull at the end of the lever arm is not to exceed 65 lb. when one side of the valve is at test pressure and other side is at atmospheric pressure. Where greater force would be required to operate the valve with a lever, provide a torque reduction gearbox operator.
8. Provide grease lubricated, worm gear type operators for torque reduction gearbox operators. Gearbox operators equipped with a hand wheel and a visual indicator of the valve position. Provide gear operators with adjustable mechanical stop-limiting devices to prevent over travel of the disc/ball/plug in the open and closed positions and which are self-locking and designed to hold the valve in any intermediate position between full open and full closed. Where gearbox operators are intended for direct bury or submergence, seal units with long life lubricant.
9. For manual valves on lines 3 inches and greater, mounted over 7.0 feet above the operating floor, provide chain wheel gear operators. Design chain wheel operators so that a force of 30 lb. is sufficient to open the valve when one side of the valve is at test pressure and the other side is at atmospheric pressure. Provide chain pulley that positively engages the chain links. The chain will extend from the valve operator to an operating height of 4 feet above the floor or as directed by the Owner. The exact dimensions will be field determined. Provide approved chain hooks where required to prevent chain from hanging within traffic paths.
10. Where manual operators are installed over 7.0 feet above the operating floor and the Drawings specify a vertical valve shaft, revise the gear operator and/or chain wheel position to provide a horizontal chain wheel shaft. Retain the valve orientation specified on the Drawings.
11. Provide ductile iron chain wheels. Provide galvanized steel operating chains.

D. Valve Stem Extensions and Wrench Nuts
1. Provide valve stem extensions where additional clearance is required for pipe insulation or where valve operation without the extension is difficult; and in manholes.
2. Where angle valve stem extensions are employed, they will be angle geared. Universal joint types are not permitted.
3. Wrench nuts shall comply with AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of wrench nut operated valves.

E. Operator Appurtenances
1. Valve Boxes: Valve boxes shall be cast iron and shall have suitable base castings to fit properly over the bonnets of their respective valves and heavy top sections with stay-put covers. Covers shall be hot-dip galvanized. Valve boxes extending to finished surfaces shall be provided for buried valves.
2. Floor Boxes: Floor boxes shall be hot-dip galvanized. Where the operating nut is in the concrete slab, the floor box shall be bronze bushed. Where the operating nut is below slab, the opening in the bottom of the box shall be sufficient for passage of the operating key. Floor boxes shall be provided for wrench operation of valves located below concrete slabs. Each floor box and cover shall be of the depth required for installation in the slab.

3. Adjustable Shaft Valve Boxes: Adjustable shaft valve boxes shall be concrete or cast iron Brooks No. 3RT, Christie G5, Empire 7-1/2 valve extension box, or equal. Box covers on water lines shall be impressed with the letter "W." Gas line covers shall be impressed with the letter "G."
4. Floor Stand: Provide floor stands with wall bracket where indicated on the drawings.

2.02 VALVE IDENTIFICATION TAGS

A. Provide valve identification tags for all valves with an identification tag number on the drawings (Mechanical and PI&D drawings).

B. Match tag numbers shown on the drawings.

C. General: Type 316 stainless steel tags, minimum 2.5-inches x 0.75 inches, with 0.1875 inch numbers and letters. Complete tag number shall be embossed on the tag. Tags shall be attached using stainless steel wire.

D. Chemical Service: Engraved Micro-surface Impact Acrylic, minimum 0.0625-inches thick, minimum 2.5-inches wide x 0.75 inches hieght. Colors to match pipe tag color scheme per Section 40 05 02. Tags shall be attached using plastic zip ties.

PART 3 EXECUTION

3.01 PREPARATION

A. The valve and piping arrangement indicated on the Drawings is based on typical dimensions for valves of the specified type. Make the necessary modifications in the piping to allow for discrepancies between the valve dimensions shown and those supplied for the Work.

B. Prior to installation of valves, field measure and check all equipment locations, pipe alignments, and structural installations. Ensure that the valve location and orientation provides suitable access to manual operators and that sufficient space and accessibility is available for hydraulic, pneumatic, and electric power actuators.

C. Where conflicts are identified, inform the Owner.

3.02 INSTALLATION

A. Install valves in conjunction with the piping specified in the Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99), and with control valves and their appurtenances specified in Section 40 06 20.13.

B. In horizontal pipe runs, other than in locations where space does not permit, install all valves (except for butterfly valves, eccentric plug valves, and trunnion ball valves) with a vertical operating shaft with the actuator at the top. In no case install a valve with the operator below the valve.

C. Unless otherwise specified on the drawings, install butterfly valves, eccentric plug valves, and trunnion ball valves with the shaft in a horizontal orientation. Install eccentric plug valves with the plug above the valve shaft centreline when the valve is full open.

D. When joining valves to pipe or fittings, do not over torque bolts to correct for misalignment.

E. Support valves in position using temporary supports until valves are fixed in place.

F. Permanently support valves to prevent transmission of loads to adjacent pipework and/or equipment.

G. Where valves are installed in plastic pipelines (PVC, CPVC, HDPE, polypropylene etc.) greater than 4-inch diameter, support valves independent of the piping and brace valves against operating loads and torque to prevent transmission of stresses to the adjacent pipework.

H. Install gate valves in the closed position.

I. Install valves which are bubble tight in one direction to provide bubble tight seal of flow in normal direction of flow unless otherwise noted or directed by the Owner.

J. Unless otherwise specified, install single seated valves with the seat downstream. Install valves at tank connections with seat away from tank. Install valves on pump discharge and suction lines with seat end towards the pump.

K. Install all valves in accordance with the manufacturer's recommendations.

L. Protect valves installed below grade with a shrink sleeve or polyethylene sheath attached to the pipe with tape wrap.

M. Wrench nuts shall be provided on buried valves, on valves which are to be operated through floor boxes, and where specified. Extended wrench nuts shall be provided if necessary so that the nut will be within 6 inches of the valve box cover.

3.03 FIELD QUALITY CONTROL

A. Field or Site Tests and Inspections per Detailed Valve Specifications.

B. Pressure test all valves in conjunction with the pipes in which the valves are installed at test pressures specified in the applicable Piping System Schedule.

END OF SECTION

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40 05 61.15

GATE VALVE, RESILIENT WEDGE

GENERAL

1. Line Size: 2 through 12 inches
2. Rated Limits: Pressure 250 psi; Temperature 100 °F

VALVE MATERIALS

1. Body: Cast Iron
2. Disc: Cast Iron
3. Disc Trim: Buna N or Urethane Rubber
4. Stem: Bronze with double or triple O-ring

VALVE CONFIGURATION

1. Valve End/Connections: Flanged, ANSI B16.1 Class 125
2. Type of Disc: Vulcanized Resilient Wedge capable of sealing in both directions.
3. Provide O-ring seal between valve body and bonnet.
4. Operator: As indicated in the Valve Schedule in the drawings.
5. Coating: Coat interior and exterior of valve with fusion bonded epoxy in accordance with AWWA C550.

SUBMITTALS

1. The following information shall be provided in accordance with Section 01 33 00:
   a. Product data
   b. NSF 61 certification

CANDIDATE MANUFACTURERS

1. Clow 2638, 2639, 2640
2. M&H Style 4067
3. Or approved equal

END OF SECTION

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40 05 62.01

PLUG VALVE, AWWA C517 STANDARD PORT

GENERAL

1. Line Size: 3 through 12 inches
2. Rated Limits: Pressure 175 psi; Temperature 125 °F
1. Line Size: 14 through 72 inches
2. Rated Limits: Pressure 150 psi; Temperature 125 °F

VALVE MATERIALS

1. Body: Cast Iron
2. Plug: Cast Iron or Ductile Iron
3. Plug Facing: EPDM
4. Seatings: Ni or Stainless Steel
5. Packing: Buna V-flex or TFE
6. Bearings: Stainless Steel
7. Grit Excluder: PTFE or Buna-N

VALVE CONFIGURATION

1. Valve End/Connections: ANSI B16.1 Class 125# Flange
2. Pattern: One-piece, Standard Port; provide 100% minimum port area of adjacent pipe for valves 4 inches and less, provide 80 to 85% port area of adjacent pipe for valves 6 to 24 inches, provide 75% minimum port area of adjacent pipe for valves 30 inches and larger
3. Reference Standard: AWWA C517
4. Installation: install with shaft in horizontal position where possible, valve seat located upstream
5. Operator: Lever/Handwheel; provide lever for valves 4 inches and smaller, totally enclosed worm gear for valves 6 inches and larger, operator components shall be sized in accordance with AWWA C504 Section 3.8.
6. Special: upper and lower journal bearings shall be replaceable, sleeve-type, corrosion resistant, and permanently lubricated; packing shall be self-adjusting chevron type replaceable without disassembling the valve

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Furnish three certified copies of a report from an independent testing laboratory certifying successful completion of proof-of-design testing conducted in accordance with AWWA C517, Section 5.2. In lieu of testing the valves at an independent testing laboratory, proof-of-design testing may be performed at the valve manufacturer's laboratory but must be witnessed by a representative of a qualified independent testing laboratory, and all test reports must be certified by the laboratory representative. Proof-of-design testing shall have been performed on not less than three 3-inch diameter valves, with all three test units demonstrating full compliance with the test standards. Failure to satisfactorily complete the test shall be deemed sufficient evidence to reject all valves of the proposed make or manufacturer's model number.
3. Provide letter of certification that valves are compatible and recommended with slurry applications.

CANDIDATE MANUFACTURERS

1. Dezurik, PEC (2”), PEC or PEF (3” through 6”).
2. Clow Valve, (3” through 6”).
3. Val Matic, Cam-Centric Series (3” through 6”).

END OF SECTION

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40 05 63.02

BALL VALVE, BRONZE/BRASS, FULL PORT

GENERAL

1. Line Size: ¼ through 2 ½ inches
2. Rated Limits: Pressure 600 psi; Temperature 400 °F (CWP)

VALVE MATERIALS

1. Body: Bronze or Brass
2. Ball: Bronze or Chrome-Plated Brass
3. Seats: PTFE or RPTFE
4. Shafts: Bronze, Brass, or Stainless Steel; blowout-proof stem

VALVE CONFIGURATION

1. Valve End/Connections: Threaded, Female; provide threaded end cap and chain in drain pipes
2. Pattern: 2 Piece; regular port
3. Ball Mount: Floating
4. Manual Operator: Lever
5. Reference Standard: MSS SP-110, NSF/ANSI/CAN 61

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Manufacturer's standard product data
3. NSF/ANSI/CAN 61 Certification

CANDIDATE MANUFACTURERS

1. Apollo 77CLF-A Series
2. Crane/Stockham T-285-BR-P-66
3. Nibco T-S-585-80-LF

END OF SECTION

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40 05 63.05

BALL VALVE, PVC

GENERAL

1. Line Size: ½ through 4 inches
2. Rated Limits: Pressure 130 psi; Temperature 140 °F

VALVE MATERIALS

1. Body: PVC; ASTM D1784 (Grade A)
2. Ball: PVC; ASTM D1784 (Grade A)
3. O-Rings: EPDM
4. Seats: PTFE
5. Shafts: PVC; ASTM D1784 (Grade A), blowout-proof ball and stem

VALVE CONFIGURATION

1. Valve End/Connections: Threaded, Female, True Union; ASTM D2464
2. Pattern: Full Port, (Non-)Vented Ball; bi-directional
3. Ball Mount: Floating
4. Manual Operator: Lever
5. Manual Operator: Lockable Handle
6. Reference Standards: ASTM F1970, NSF/ANSI 61

SUBMITTALS

1. Shop drawings: Submit the following as specified in Sections 01 33 00 and 40 05 60:
2. Manufacturer's standard product data.
3. Manufacturer's data indicating acceptable for use with intended fluid service.
4. NSF/ANSI 61 Certification

CANDIDATE MANUFACTURERS

1. Hayward, TBH Series. (¼"- 4")
2. Asahi America, T-21 Series. (1/2" – 4")
3. Chemtrol Division, Nibco
4. Approved Equal

END OF SECTION

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40 05 63.06

BALL VALVE, CPVC

GENERAL

1. Line Size: ½ through 4 inches
2. Rated Limits: Pressure 130 psi; Temperature 140 °F

VALVE MATERIALS

1. Body: CPVC; ASTM D1784 (Grade A)
2. Ball: CPVC; ASTM D1784 (Grade A)
3. O-Rings: EPDM or FKM
4. Seats: PTFE
5. Shafts: CPVC; ASTM D1784 (Grade A), blowout-proof ball and stem

VALVE CONFIGURATION

1. Valve End/Connections: Threaded, Female, True Union; ASTM D2464
2. Pattern: Full Port, Non-Vented Ball; bi-directional.
    a. Sodium Hypochlorite Service: Full Port, Vented Ball
3. Ball Mount: Floating
4. Manual Operator: Lockable Handle
5. Reference Standards: ASTM F1970, NSF/ANSI 61

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Manufacturer's standard product data.
3. Manufacturer's data indicating acceptable for use with intended fluid service
4. NSF/ANSI 61 Certification.

CANDIDATE MANUFACTURERS

1. Hayward, TBH Series. (¼"- 4")
2. Asahi America, T-21 Series. (1/2" – 4")
3. Chemtrol Division, Nibco
4. Sodium Hypochlorite Service: Chemtrol Type 21 or Hayward TBH-Z Series
5. Approved Equal

END OF SECTION

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40 05 64.03

BUTTERFLY VALVE, HIGH-PERFORMANCE SOFT-SEATED

GENERAL

1. Line Size: 2 through 48 inches
2. Rated Limits: Pressure 125 psi; Temperature 450 °F

VALVE MATERIALS

1. Body: Stainless Steel (316 or 317)
2. Disc: Stainless Steel (316 or 317)
3. Disc Trim: Stainless Steel (316 or 317)
4. Seats: RPTFE; seats to be bonded to a rigid reinforcing ring
5. Shaft: Stainless Steel (316, 17-4PH, or XM-19)
6. Packing: Graphite or PTFE V-Ring
7. Bearings: 316 SS-backed PTFE

VALVE CONFIGURATION

1. Valve End/Connections: Lugged or Flanged, ASNI B16.1 Class 150
2. Type of Disc: Eccentric Mount
3. Manual Operator: Lever/Handwheel; provide geared operators for valves 6 inches and larger
4. Reference Standard: AWWA C504, NSF/ANSI 61

SUBMITTALS

1. As required in Section 40 05 60.
2. Manufacturer's standard data including product literature, materials of construction, construction details of equipment, and weight of equipment.
3. Affidavits of compliance with AWWA C504.
4. Documentation of compliance with ANSI/NSF 61

CANDIDATE MANUFACTURERS

1. Bray McCannalok Series 41
2. Crane Flo-Seal
3. Dezurik BHP
4. Fisher 8580
5. GE Masoneilan 39003

END OF SECTION

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40 05 64.05

BUTTERFLY VALVE, AWWA C504, CLASS 150B

GENERAL

1. Line Size: 3 through 48 inches
2. Rated Limits: Pressure 125 psi; Temperature 120 °F

VALVE MATERIALS

1. Body: AWWA C504, Class 150B, Short Body
   a. Cast Iron, ASTM A126, Class B
   b. Ductile Iron, ASTM A536, Grade 65-45-12
2. Disc:
   a. Ductile Iron, ASTM A536, Grade 65-45-12 with 316 Stainless steel edge
   b. Stainless Steel, Type 316 ASTM A743
3. Seats:
   a. Acrylonitrile-Butadiene (NBR)
   b. Buna-N
   c. EPDM
   d. For valves 24 inches and larger, provide valve seats with seals vulcanized bonded, mechanically secured, or clamped to the body, valve seats to be field adjustable and field replaceable.
4. Shaft: Type 316 Stainless Steel, ASTM 276
   a. For valves 24-inch and larger Type 304 or 316 Stainless Steel, ASTM A276.
5. Shaft Packing: V-Type Chevron
   a. Buna-N, Acrylonitrile-Butadiene (NBR), or EPDM

VALVE CONFIGURATION

1. Valve End/Connections:
   a. Flange, Class 125 Faced and Drilled per ANSI B16.1
2. Type of Disc: Concentric or Eccentric
3. Manual Operator: Lever or Handwheel; provide geared operators for valves 6 inches and larger
4. Valve Direction to Open: Counterclockwise
5. Reference Standard: AWWA C504

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Manufacturer's standard data including product literature, materials of construction, construction details of equipment, and weight of equipment.
3. Affidavits of compliance with AWWA C504.
4. Documentation of compliance with ANSI/NSF 61

CANDIDATE MANUFACTURERS

1. Homestead Series 820 (3" – 24")
2. DuZurik BAW (3" – 48")
3. Pratt TRITON® XR-70 (24" – 48")
4. Valmatic American-BFV 2000 Series (3" through 48")

END OF SECTION

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40 05 65.07

CHECK VALVE, GLOBE STYLE SILENT PLUG

GENERAL

1. Line Size: 12 through 36 inches
2. Rated Limits: Pressure 150 psi; Temperature 150 °F

VALVE MATERIALS

1. Body: Cast Iron or Ductile Iron
2. Plug: Bronze
3. Seats: Bronze
4. Screw: Stainless Steel (304 or 316)
5. Spring: Stainless Steel (304 or 316)
6. Bushing: Bronze

VALVE CONFIGURATION

7. Valve End/Connections: Flanged, ANSI B16.1 Class 125
8. Check Mechanism: Plug, Silent Check
9. Body: Globe Style

SUBMITTALS

1. As required in Section 01 33 00 and 40 05 06.
   a. Product data
   b. Operation and maintenance data
   c. Certification that the products used are suitable for contact with drinking water in accordance with NSF Standard 61

CANDIDATE MANUFACTURERS

1. APCO 600
2. Val-Matic Series 1800A

END OF SECTION

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40 05 65.10

CHECK VALVE, BALL TYPE IRON BODY

GENERAL

1. Line Size: 2 through 14 inches
2. Rated Limits: Pressure 145 psi; Temperature 175 °F

VALVE MATERIALS

1. Body: Ductile Iron, ASTM A 536
2. Cover: Ductile Iron, ASTM A 536
3. Ball: Floating hollow metal (aluminum or steel) ball filled with foundry sand, with nitrile or Buna-N coating
4. Bolts and Nuts: Stainless steel

VALVE CONFIGURATION

1. Valve End/Connections: ANSI B16.1 Class 125# Flange
2. Check Mechanism: Fully automatic floating ball check
3. Maintenance: Valve shall be constructed with bolted lifting cover that allows for access and removal of floating ball without removal of the valve from the piping.

SUBMITTALS

1. As required in Section 01 33 00 and 40 05 60.
2. Valve and coating certification.
3. Affidavits of compliance with AWWA C504.
4. Documentation of compliance with ANSI/NSF 61

CANDIDATE MANUFACTURERS

1. Golden Anderson 240/242

END OF SECTION

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40 05 65.12

STAINLESS STEEL, AIR/GAS SERVICE, SPLIT DISC, 400 DEGREE F RATED

GENERAL

1. Line Size: 2 through 36 inches
2. Rated Limits: Pressure 175 psi; Temperature 400 °F

VALVE MATERIALS

1. Body: ASTM A351, CF-8M Stainless Steel
2. Disc: ASTM A351, CF-8M Stainless Steel
3. Seals: ASTM A351, CF-8M Stainless Steel
4. Hinge Pin: Stainless Steel (316)
5. Spring: Inconel X-750® Nickle-chromium alloy

VALVE CONFIGURATION

1. Valve End/Connections: Lugged, ASME B16.5 Class 150
2. Check Mechanism: Split Disc/Double Leaf
3. Special: provide lifting lugs on valves greater than 100 lb., valves shall open with not more than 0.5 psig differential pressure and be sprung such that the doors shut without slamming

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Action Submittals:
   a. Certified Hydrostatic and Seat Test Report

CANDIDATE MANUFACTURERS

1. APCO 9000T
2. Crane Duo-Check
3. Approved Equal

END OF SECTION

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SECTION 40 05 65.23

SWING CHECK VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies spring-loaded swing check valves.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A536	Ductile Iron Castings
ASTM B148	Aluminum-Bronze Sand Castings
AWWA C508	Swing-Check Valves for Waterworks Service, 2 In. Through 24 In. NPS

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. APCO Model 250
   2. Crispin, SWL Series
   3. Golden Anderson 240/242
   4. Mueller, A-2600
   5. Or approved equal.

2.02 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Body, cover	Ductile iron, ASTM A536
Disc	Ductile iron, ASTM A536
Seat rings	Aluminum bronze, ASTM B148 or Stainless steel, ASTM A276, Type 316
Hinge shafts and hinge pins	Stainless steel, ASTM A276, Type 301 or 304
Shaft bushings	Bronze, AWWA C508

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 MANUFACTURE

A. Disc, disc arm, shaft, keyways, lever and spring shall be capable of closing within .05 seconds of pump stoppage and fluid moving at velocity of 8 feet per second. Spring tension shall be adjustable. The valve design shall permit mounting levers and springs on either side of the valve. The design of the spring attachment shall permit adjustment of closing force by tensioning the spring or replacement with different active length springs.

B. Valves shall be provided with a clear opening equal to or greater than the connecting piping, with no raised seating surface. Seats shall be threaded onto the body or fitted with an O-ring seal and locked in place with stainless steel screws or pins and shall be replaceable. Shafts shall be provided with stuffing box and packing or O-ring seals at each end. Seals shall be externally replaceable.

C. The pivot arm shall be secured to the disc with either twin bolted connections with lockwashers or a pinned nut. In either instance, the connection shall be designed to prevent disc movement relative to the arm. Shaft bearings shall extend the entire length of the shaft other than the section required for the disc arm attachment. Disc and lever arms shall be keyed to the shaft and retained by bushings or pins.

D. Unless otherwise specified, valves shall, as a minimum, conform to the following pressure ratings:

Size, inches	Working pressure, pressure, PSIG	Hydrostatic shell test
2 through 36	250	500

E. Check valves wetted parts shall be coated with fusion bonded epoxy.

2.04 PRODUCT DATA

A. Manufacturer's catalog information including dimensions, cross-sectional views, details of construction and materials list shall be provided in accordance with Section 01 33 00.

2.05 LINING AND COATING

A. Valve shall be lined with 12 mils and coated with 8 mils of NSF 61 certified fusion bonded epoxy.

PART 3 EXECUTION

3.01 INSTALLATION

A. Spring loaded swing check valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

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40 05 65.25

CHECK VALVE, PVC SWING TYPE

GENERAL

1. Line Size: ¾ through 8 inches
2. Rated Limits:
   a. Pressure 70 psi; Temperature 70 °F, Non-shock (3/4" – 3"),
   b. Pressure 100 psi; Temperature 120 °F, Non-shock (4" – 6"),
   c. Pressure 150 psi; Temperature 120 °F, Non-shock (8"),

VALVE MATERIALS

1. Body: PVC, ASTM D1784
2. Bonnet: PVC, ASTM D1784
3. Disc: PVC, ASTM D1784
4. Seats, Gasket: EPDM, PTFE, or FKM
5. Hinge Pin: PVC, ASTM D1784
6. Fasteners: Stainless Steel (304 or 316)
   a. **(Sodium Hypochlorite Service)** Hastelloy C 276 (UNS 10276) Bolts: ASTM F467, and Hastelloy C 276 (UNS 10276) Nuts: ASTM F468

VALVE CONFIGURATION

1. Valve End/Connections: Flange, ANSI Class 150
2. Type: Bonneted Flap Style Check

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Manufacturer's standard product data.
3. Manufacturer's data indicating acceptable for use with intended fluid service.
4. NSF/ANSI 61 Certification

CANDIDATE MANUFACTURERS

1. Hayward SW Series (3" – 8")
2. Asahi (3/4" – 8")
3. Spears
4. Approved Equal

END OF SECTION

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40 05 65.26

CHECK VALVE, CPVC SWING TYPE

GENERAL

1. Line Size: ¾ through 8 inches
2. Rated Limits: Pressure 70 psi; Temperature 73 °F
   a. Pressure 70 psi; Temperature 70 °F, Non-shock (3/4" – 3"),
   b. Pressure 100 psi; Temperature 120 °F, Non-shock (4" - 6"),
   c. Pressure 150 psi; Temperature 120 °F, Non-shock (8")

VALVE MATERIALS

1. Body: Polypropylene or CPVC, ASTM D1784
2. Bonnet: Polypropylene or CPVC, ASTM D1784
3. Disc: Polypropylene or CPVC, ASTM D1784
4. Seats, Gasket: EPDM, PTFE, or FKM
5. Hinge Pin: Polypropylene or CPVC, ASTM D1784
6. Fasteners: Stainless Steel (304 or 316)

VALVE CONFIGURATION

1. Valve End/Connections: Flange, ANSI Class 150
2. Type: Bonneted Flap Style Check
3. Reference Standards: ASTM F1970, NSF/ANSI 61

SUBMITTALS

1. As required in Section 40 05 60 – Valves.
2. Manufacturer's standard product data.
3. Manufacturer's data indicating acceptable for use with intended fluid service.
4. NSFL/ANSI 61

CANDIDATE MANUFACTURERS

1. Hayward SW Series (3" – 6")
2. Approved equal

END OF SECTION

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40 05 66.01

GLOBE VALVE, BRONZE

GENERAL
1. Line Size: ¼ through 3 inches 2. Rated Limits: Pressure 125 psi; Temperature 353 °F (Steam) Pressure 300 psi; Temperature 100 °F (WOG)
VALVE MATERIALS
1. Body: Bronze ASTM B584 2. Disc: Bronze ASTM B584 3. Seats: Brass ASTM B21 4. Stem: Brass ASTM B21
VALVE CONFIGURATION
1. Valve End/Connections: NPT Threaded, Female 2. Manual Operator: Handwheel; rising stem 3. Reference Standard: MSS SP-80, ANSI/NSF 61
SUBMITTALS
1. As required in Section 40 05 60 – Valves. 2. Manufacturer's standard product data 3. NSF/ANSI 61 Certification
CANDIDATE MANUFACTURERS
1. Milwaukee UP502 2. Approved Equal

END OF SECTION

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40 05 66.23

NEEDLE VALVE

GENERAL
1. Line Size: 1/8 through 3/8 inches 2. Rated Limits: Pressure 3000 psi; Temperature -20 to 200 °F
VALVE MATERIALS
1. Body: Brass (377/B283) 2. Stem: 316 Stainless Steel A276 3. Seats: 316 Stainless Steel 4. Seals/Packing: PFA D3307
VALVE CONFIGURATION
1. Valve End/Connections: Threaded, Female or Compression 2. Flow Pattern: Straight 3. Stem Design: Vee 4. Operator: Screwed Bonnet, Round Handle
SUBMITTALS
1. As required in Section 40 05 60 – Valves. 2. Manufacturer's standard product data
CANDIDATE MANUFACTURERS
1. Swagelok Integral Bonnet Needle Valves; 0, 1 or 18 Series 2. Approved Equal

END OF SECTION

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SECTION 40 05 67.13

REDUCED-PRESSURE ZONE BACKFLOW PREVENTERS FOR PROCESS SERVICE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies reduced pressure principle backflow preventers.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA C511	Standard for Reduced-Pressure Principle Backflow Prevention Assembly

B. Testing:
   1. Backflow preventers shall meet the factory, laboratory and field test provisions of AWWA C511.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Cla-Val, Febco, Watts, or equal.

2.02 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Affidavit of Compliance with AWWA C511.
   2. Certificate of Approval as specified in AWWA C511.

PART 3 EXECUTION

3.01 INSTALLATION

A. Backflow preventers shall be installed in accordance with the manufacturer's instructions.

END OF SECTION

SECTION 40 05 67.36

PRESSURE-REGULATING VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies direct acting and pilot controlled pressure regulating valves for air, water and chemical service including pressure regulating/relief valves (PRVs), pressure safety valves (PSVs) and back-pressure regulating valves (BPVs).

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.5	Pipe Flanges and Flanged Fittings

   3. Additional Sections and Paragraphs Required for Compliance:
      a. The equipment specified in this section shall be provided in accordance with the following additional sections and paragraphs. This is not a comprehensive list of related and referenced sections and paragraphs and additional related and referenced sections and paragraphs requiring compliance may be specified throughout this section and within other sections.
         1) Section 01 33 00 – Submittal Procedures.
         2) Section 01 99 90 – Reference Forms.
         3) Section 43 05 11 - General Requirements for Equipment.

B. Unit Responsibility:
   1. The Manufacturer shall take Unit Responsibility for the valves as specified in Section 43 05 11.

2. Unit Responsibility extends to all equipment, accessories and all coordinating items provided by the Contractor required for a fully functioning unit. This includes items specified in this Section, accessories or items referenced to other Sections, whether provided by the Manufacturer or the Contractor.
3. A completed, signed, and notarized Certificate of Unit Responsibility (Section 01 99 90-Form 43 05 11-C) shall be provided.

C. Performance:
1. Direct acting type pressure regulating valves shall control the discharge pressure within ±5 percent of set pressure.
2. Pilot controlled type pressure regulating valves shall maintain the set discharge pressure regardless of fluctuations in inlet pressure.

D. Testing:
1. Hydrostatic tests shall be conducted by the manufacturer for one valve of each type supplied for a particular service. Steel-bodied valves shall be hydrostatically tested in accordance with the requirements of ANSI B16.5. Aluminum-, bronze-, and brass-bodied valves shall be hydrostatically tested at double the MAX pressure specified. Leakage, sweating or visible deformation at any point on the valve shall be cause for rejection of valves of that type and manufacture.

1.03 SUBMITTALS

A. As required in Section 40 05 60 – Valves.

B. Action Submittals:
1. Procedures: Section 01 33 00 – Submittal Procedures
2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.

C. Information Submittals:
1. Procedures: Section 01 33 00 – Submittal Procedures
2. The Contractor shall provide certified copies of test reports specified in paragraph 1.02 Testing.

PART 2 PRODUCTS

2.01 REQUIREMENTS

A. General:
   1. Pressure regulating valve connections shall be as specified in the piping system schedules.
   2. Moving parts requiring lubrication shall have means provided for lubrication and shall be lubricated prior to delivery.

B. Pressure regulating/relief valves (PRVs).
   1. Water Service:
      a. Valves less than 1-1/4 inches shall be direct acting, spring-operated type. Valves less than 1-1/4 inches shall be Cash-Acme E-41 Series 3, Watts LF223, or equal, with separate Y-pattern strainer.
      b. Valves 1-1/4 inches and larger shall be pilot-controlled type, unless otherwise specified. Valves 1-1/4 inches and larger shall be diaphragm actuated type or differential piston pressure type and shall be Cla-Val Co. Clayton 90-01 Series, GA Industries, Inc., or equal.
   2. Air Service:
      a. Valves for air service shall be Cash-Acme E-41 Series 3, Watts 152A, or equal, with separate Y-pattern strainer.
   3. Chemical Service
      a. Adjustable pressure relief type valves for chemical service shall be suitable for the chemical solution service specified and shall be installed on pump discharge at the feed panel as shown the drawings.
      b. Valves shall be sized to handle a maximum flow through the valves of not less than 1.5 times the maximum flow supplied by the associated pump.
      c. Pressure relief valves shall be Griffco, Plast-O-Matic, or equal.
      d. Valve body:
         1) For acetic acid, phosphoric acid, and sodium hydroxide service, the valve body shall be SS-316L.
         2) For ACH service, the valve body shall be PVC.
         3) For hydrogen peroxide service, the valve body shall be SS-316L.
         4) For sodium hypochlorite service, the valve body shall be FRP.
      e. Diaphragm
         1) The diaphragm material shall be PTFE.

C. Pressure Safety Valves (PSVs):
   1. Valves for air service shall be ASME certified, Watts Figure 41A, Lonergan L14/L40 Series, or equal.
   2. Valves for CO2 service shall be ASME certified. Size, type, and materials of construction shall be selected by the CO2 system supplier and shall be compatible with CO2 service as recommended by CO2 system supplier.

D. Back Pressure Regulating Valves (BPVs):
   1. Backpressure valves for chemical service shall apply a continuous discharge back pressure downstream of the metering pumps and serve as anti-siphoning valves. Backpressure valves shall be non-metallic and suitable for the pumped liquid characteristics. Backpressure valves shall match line size as shown on drawings. Backpressure valves shall be adjustable from 10-150 psi with a tamper-resistant adjustment screw. The valves shall be as close to the pump discharge as feasible, but downstream of pulsation dampeners and pressure gauges. Adjustable diaphragm backpressure regulating type valves shall be installed on pump discharge as shown on the drawings. Valve shall be suitable for the chemical solution service specified.
   2. Back-pressure valves shall be Griffco, Plast-O-Matic, or equal.
      a. Valve body:
         1) For acetic acid, phosphoric acid, and sodium hydroxide service, the valve body shall be SS-316L.
         2) For ACH service, the valve body shall be PVC.
         3) For hydrogen peroxide service, the valve body shall be SS-316L.
         4) For sodium hypochlorite service, the valve body shall be PVC.
      b. Diaphragm
         1) Diaphragms shall be PTFE.

2.02 ACCEPTABLE PRODUCTS

A. General:
   1. Pressure regulating valves shall be flanged or threaded connections as specified. Moving parts requiring lubrication shall have means provided for lubrication and shall be lubricated prior to delivery.
   2. Valves less than 1-1/4 inches shall be direct acting, spring-operated type. Valves less than 1-1/4 inches shall be Cash-Acme E-41 Series 3, Watts 223, or equal, with separate Y-pattern strainer.
   3. Valves 1-1/4 inches and larger shall be pilot-controlled type, unless otherwise specified. Valves 1-1/4 inches and larger shall be diaphragm actuated type or differential piston pressure type and shall be Cla-Val Co. Clayton 90-01 Series, GA Industries, Inc., or equal.

B. Air Service:
   1. Valves for air service shall be Cash-Acme E-41 Series 3, Watts 152A, or equal, with separate Y-pattern strainer.

C. Chemical Service:
   1. Valves for chemical service shall conform to all AGA regulations and criteria. Valves shall be sized as recommended by the manufacturer for the intended use.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's product data.
   2. Hydrostatic test results.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pressure regulating valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

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SECTION 40 05 72

SPECIALTY VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies specialty valves which are auxiliary to process piping systems.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASME SEC VIII D2	Boiler and Pressure Vessel Code, Pressure Relief Devices
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings

1.03 SUBMITTALS

A. As required in Section 40 05 60 – Valves

B. Action Submittals:
   1. Procedures: Section 01 33 00 – Submittal Procedures

2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.

C. Information Submittals: None

PART 2 PRODUCTS

2.01 SHEAR GATES (NOT USED)

2.02 FLAP GATES

A. Flap gates shall be heavy-duty, double-hinge type. Body and cover shall be cast iron conforming to ASTM A126, Class B. The body shall be provided with a resilient neoprene seat bonded in a groove machined in the body. The seal shall provide positive shutoff. The cover shall have a phosphor bronze seat facing, securely mounted in a dovetail groove around the periphery of the gate opening. Upper pivot shall be adjustable for gate sensitivity, and lower pivot shall incorporate a provision to align the cover. Gate design shall prevent cover from wedging into gate opening. Lubrication fittings shall be provided for each pivot.

B. Unless otherwise specified, wall thimbles shall be minimum 8-inch deep F-section, formed of ASTM A126, Class B cast iron with the gate mounting face machined flat to form a true bearing surface.

C. Thimble opening shall be the same as the gate size specified on the drawings. All anchor bolts shall be hot-dip galvanized. Fasteners and bushings shall be naval bronze.

D. Flap gates shall be Rodney Hunt Series FV-AC or FV-ACP, Waterman F-55, or equal.

2.03 KNIFE GATE VALVES

A. Electrically actuated knife gate valves shall be of a wedge design wherein the sealing gasket shall not be in constant contact with the blade while opening or closing. The blade shall move upward at the closing point to provide a watertight seal and include an "anti-racking" mechanism to prevent the gate from becoming misaligned during operation. Gates and actuators shall be furnished with all necessary parts and accessories required for a complete and fully functional unit.
   1. Gate valve and fasteners material shall all be type 304/304L stainless steel.
   2. In the closed position the knife gate valve blade deflection shall not exceed 1/360th of the maximum gate span based on 1200 lb./ft2 loading. Manufacturer shall submit calculations verifying this requirement.
   3. The blade shall be supported on heavy-duty stainless-steel rollers with a minimum diameter of 1.5 inches with pre-lubricated sealed bearings.
      a. Roller and bearing assembly shall be located out of the material flow.
      b. Bearings shall have a minimum 100,000 hours AMBA L10 rating life.
   4. Electric actuator shall be in accordance with Section 40 05 57.23 – Powered Actuators.

B. Submittals shall be in accordance with Section 40 05 60 – Valves and Section 40 05 57.23 – Powered Actuators.
   1. For the applications of seed silo and pellet storage hopper, knife gate valves and electric actuators shall require approval from pellet softening System Supplier or pellet storage hopper Supplier, respectively, that selected products conform to all requirements of supplier's unit responsibility for a fully functional system which reliably operates in a manner such that potential for bridging is minimized.

2.04 MUD VALVES

A. Unless otherwise specified, mud valves shall be iron body, bronze mounted, flange type with nonrising stems. Stems shall be bronze with steel extension shafts where indicated. Operating nuts shall be enclosed in floor boxes or mounted on angle supports as specified and shall be suitable for operation with T-handle wrenches provided with the valves. Operating nuts shall be AWWA standard size. Mud valves shall be Clow F-3080, Waterman MV-11, or equal.

B. Provide extension stems to the operating floor and intermediate guides as recommended by the manufacturer and as required in Section 40 05 60.

C. Valve boxes shall be stainless steel cannister and cover with bolted lid, O-ring seal, bushing, position indicator and operating nut.

D. Manufacturers
   1. Trumbull
   2. Approved Equal.

2.05 PRESSURE RELIEF VALVES

A. Pressure relief valves for air shall be ASME certified, Watts Fig 41A, Lonergan L14/L40 Series, or equal. Size and pressure settings shall be as specified or as required for the service intended. Pressure relief valves for cold and hot water shall be McDonnell and Miller 230, Watts 174A, Cash Acme F-82, Lonergan L14/L40 Series, or equal.

2.06 COMBINATION TEMPERATURE-PRESSURE RELIEF VALVES

A. Combination temperature-pressure relief valves for use with boilers and hot water storage tanks shall be ASME certified and rated.

B. Valves shall be provided with a safety relief testing lever. Connections shall be threaded type.

C. Valves shall be Watts 40-140-N240-340 series, Cash Type NCLX, or equal.

2.07 HOSE VALVES

A. Unless specified otherwise, hose valves shall be a brass angle valve, composition disc, Crane 17, Lunkenheimer 214, Powell 151, or equal with threaded nipple adapter for hose connection.

B. Submerged hose valve shall be 316 stainless steel and NSF/ANSI/CAN 61 certified.

2.08 FLUSHING COCKS

A. Flushing cocks shall consist of a DeZurik 159/118-S, Keystone Fig 541, or equal, neoprene-faced eccentric plug valve with a hose nipple adapter if required. Unless specified otherwise, flushing cocks shall be 1 inch in diameter.

2.09 QUICK DISCONNECTS

A. Quick disconnects shall not be disconnectable under pressure. Quick disconnects for air service shall be Swagelok, Tomco, or equal, and shall be 1/2 inch, unless otherwise specified. Quick disconnects for water service shall be EverTite Part B, Gate Part B, or equal, and shall be 1 inch, unless specified otherwise.

2.10 STOP AND DRAIN VALVES

A. Stop and drain valves shall be Mueller H-10284, or equal.

2.11 VACUUM RELIEF VALVES – CHEMICAL SERVICE

A. Pressure and vacuum relief valves shall be provided for acetic acid bulk storage tanks. To allow air to enter the tank during drain down operations, and not allow air out during filling.
   1. Maximum Liquid Flowrate: 86 gpm
   2. Valve Size: 6-inch
      a. Contractor to confirm size and pressure settings as required for the service intended.

3. Valve Set Point: 0.5 psig.
    a. Pressure and vacuum vent shall not restrict the flow of air, induce a pressure, or vacuum on the tanks. Contractor to coordinate final size requirements with tank manufacturer (Section 43 41 13) and vent scrubber manufacturer (Section 44 31 19) prior to equipment fabrication.

B. Materials of Construction
    1. Housing/Body: Type 316 SS
    2. Pallet: Type 316 SS
    3. Pallet Diaphragm: Teflon (FEP) Film
    4. Weight Material: Type 316 SS

C. Manufacturer
    1. Protectoseal 6240 Series
    2. Approved equal.

2.12 RUBBER DUCKBILL CHECK VALVES

A. The check valve between the South Platte Forebay and the Raw Water Blend Tank shall be Rubber Duckbill type that allows flow in the direction shown on the drawings and prevents flow in the reverse direction.

B. Design

    1. Cracking pressure to open the valve shall be less than 2-inch.

    2. Headloss through the valve at 5600 gpm shall be less than 6-inch.

    3. Maximum water depth above valve centerline on the upstream side is 8 feet.

C. Materials of construction:

    1. ANSI/CAN/NSF 61-600 Certified suitable for service in potable water.

    2. Duckbill: one-piece EPDM elastomer matrix with internal fabric reinforcing.

    3. Flange: integral with the nozzle and fabric reinforcing spanning across the joint between the flange and nozzle body.

    4. Flange drilling: ANSI B16.1 Class 125/ANSI B16.5, Class 150 standards.

    5. Backing/retainer ring: stainless steel 316.

    6. Flange bolts: 316 stainless stee

    7. l.

D. Manufacturer

    1. Red Valve, 35 Series

2. Proco, 710 Series

3. Approved Equal

2.13 PRODUCT DATA

A. Manufacturer's product data shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 INSTALLATION

A. Specialty valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

40 05 72.82

DEGASSING VALVE, CPVC

GENERAL

1. Line Size: ½ inch
2. Rated Limits: Pressure 100 psi; Temperature 85 °F

VALVE MATERIALS

1. Body: CPVC
2. Float: Polypropylene
3. Linkage: CPVC
4. Seals: Viton

VALVE CONFIGURATION

1. Valve End/Connections: THD

SUBMITTALS

1. As required in Section 40 05 06 - Valves
   a. Manufacturer's standard product data
   b. Manufacturer's data indicating acceptable for use with intended fluid service
   c. NSF / ANSI 61 Certification

CANDIDATE MANUFACTURERS

1. Plast-o-Matic DGV Series

END OF SECTION

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SECTION 40 05 78.13

AIR/VACUUM VALVES FOR WATER SERVICE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies air release valves, air and vacuum valves, and combination air valves for clean water service, pumping, and storage applications.

B. Types:
   1. Air Release Valves: Air release valves (ARV) shall have a small venting orifice to vent the accumulation of air and other gases with the line or system under pressure. Size and capacity shall be as specified.
   2. Air and Vacuum Valves: Air and vacuum valves (AVV) shall have a large venting orifice to permit the release of air as the line is filling or relieve the vacuum as the line is draining or is under negative pressure. Size and capacity
   3. Combination Air Valves: Combination air valves (CAV) shall have operating features of both the air and vacuum valve and the air release valve. They include both single- and dual-body construction. Size and capacity shall be as specified.
   4. Combination Air and Vacuum Break Zero Pressure: Combination air release and vacuum break valves (CAVZ) shall seat with zero psi pressure and shall have operating features of both the air and vacuum valve and the air release valve. Size and capacity shall be as specified.
   5. Air Valves for Vertical Turbine Pumps: Air valves for vertical turbine pumps (ATP) shall consist of an air and vacuum valve with throttling device for sizes 3-inch and less, and a dual body construction combination air valve mounted on top of a surge check for sizes 4-inch and larger. Size and capacity shall be as specified.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A240	Heat-Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

1.03 SUBMITTALS

A. As required in Section 40 05 60 – Valves

B. Action Submittals:
   1. Procedures: Section 01 33 00 – Submittal Procedures
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will cfm signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.

C. Information Submittals:
   1. Procedures: Section 01 33 00 – Submittal Procedures
   2. Applicable O&M instruction manuals per Section 01 78 23.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Air release and vacuum valves shall be APCO as manufactured by Valve and Primer Corporation, Crispin as manufactured by Multiplex Manufacturing Company, or equal, modified to provide the specified features and to meet the specified operating conditions.

B. Combination air release and vacuum break zero pressure valves shall be Vent Tech Model WZW.

2.02 MATERIALS

A. Air and Vacuum Valves (ARV, AVV, CAV, and ATP)

Component	Material
Body, cover	Cast iron, ASTM A126, Grade B
Float	Type 316 SS, ASTM A240
Seat	Buna-N or Type 316 SS
Trim	Type 316 SS, ASTM A240

B. Combination Air and Vacuum Break Zero Pressure Valves (CAVZ):

Component	Material
Body, cover	Type 316 SS, ASTM A240
Float	Type 316 SS, ASTM A240
Seat	Type 316 SS, ASTM A240
Trim	UHMW-PE

C. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 CONSTRUCTION

A. Air release valves shall be float operated, compound lever type, except air release valves less than 1-inch may be simple lever type.

B. Air and vacuum valves shall be designed to protect the float from direct contact of the rushing air and water to prevent the float from closing prematurely in the valve. The seat shall be fastened into the valve cover and shall be easily removed if necessary. The float shall be center or peripheral guided for positive shutoff into the seat.

C. Combination air valves, unless otherwise specified, shall be single-body construction in sizes 1- through 6-inch and dual-body construction in sizes 8-inch and larger. Single-body construction shall be designed to provide all functions within one housing. The body inlet shall be baffled to protect the float and the large and small orifices shall be designed so that during large orifice closure, the small air release orifice will open to allow small amounts of air to escape. Dual-body construction shall combine one air and vacuum valve and one air release valve with interconnecting piping and gate valve.

D. Combination air release and vacuum break zero pressure valves shall be tubular, single chamber design with anti-surge, nozzle, and control floats. Valves shall include a lower bleed port for depressurizing the valve. The valve shall be designed to form an airtight seal at an internal pressure of zero (0) psi.

E. Air valves for vertical turbine pumps (sizes 3-inch and less) shall be designed and constructed as specified for air and vacuum valves except the discharge orifice shall be fitted with a throttling device to regulate and restrict air venting and establish a pressure

loading on the rising column of water on pump start. Unless otherwise specified, air valves, 4-inch and larger, shall be dual body combination air valves except the inlet shall be fitted with a surge check to prevent water column entering the valve on pump start.

F. Valves shall be suitable for pressures up to 150 psi.

2.04 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's product data.
   2. Applicable O&M instruction manuals per Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Air release and vacuum valves shall be installed in accordance with the manufacturer's recommendations. Unless otherwise specified, isolation valves per Section 40 05 01 shall be provided below each air valve.

END OF SECTION

SECTION 40 05 82

SOLENOID VALVES FOR PROCESS SERVICE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies 2- and 3-way solenoid valves, direct or pilot operated type, for control of process fluids. Valves for air cylinder pilot duty are specified in Section 40 05 57.23.

B. Type:
   1. Valves with piping connections less than 1-1/2 inches in diameter shall be direct-acting type.
   2. Valves with piping connections 1-1/2 inches in diameter and greater shall be pilot operated globe body type.

C. Design Requirements:
   1. Unless otherwise specified, solenoid valves shall be designed to seal or unseal the pressurized (supply) port upon the action specified in the paragraph 1.03.
   2. Valves shall be listed by Underwriters Laboratories Inc. in accordance with UL 429 and UL 1002. Solenoid valves for gas service shall be approved by Factory Mutual Engineering Corporation. The minimum acceptable operating pressure differential for pilot operated valves shall be 5 psi.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A48	Gray Iron Castings
UL 429	Electrically Operated Valves
UL 1002	Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G

1.03 SUBMITTALS

A. As required in Section 40 05 60 – Valves

B. Action Submittals:
   1. Procedures: Section 01 33 00 – Submittal Procedures
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.

C. Information Submittals:
   1. Procedures: Section 01 33 00 – Submittal Procedures
   2. Applicable O&M instruction manuals per Section 01 78 23.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

B. Direct Acting Type:
   1. Candidate manufacturers include:
      a. Automatic Switch Company (ASCO)
      b. Honeywell-Skinner
      c. or equal

C. Pilot Type:
   1. Candidate manufacturers include:
      a. Cla-Val Co.
      b. Golden Anderson

c. or equal

2.02 MATERIALS

A. Direct Acting Type:

1. Materials of construction shall be as follows:

Component	Material
Body	Brass or stainless steel, Type 304
Seal	Teflon or Buna-N
Disc	Teflon or Buna-N

B. Pilot Type:

1. Materials of construction shall be as follows:

Component	Material
Main valve body	Cast iron, ASTM A48
Pilot control body	Brass

2.03 EQUIPMENT

A. General:

1. Solenoid valves shall be rated for continuous duty at 24 volts DC or 120 volts AC as indicated. Valves shall be threaded for sizes 2-inch and smaller and flanged for sizes 2-1/2 inch and larger.

B. Direct Acting Type and Pilot Type:

1. Solenoid valves shall be suitable for the area location and usages as indicated in the schedule with fully encapsulated Class H coils. Enclosure type:
   a. NEMA 1 general purpose, molded epoxy construction
   b. NEMA 4X watertight / dust tight / corrosion resistant
   c. NEMA 6P submersible
   d. NEMA 7 explosion proof

C. Unspecified solenoid valves enclosures shall be NEMA 4X.

2.04 PRODUCT DATA

A. Manufacturer's product data shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 INSTALLATION

A. Solenoid valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

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SECTION 40 05 EE

THERMOPLASTIC PROFILE WALL PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section includes construction polyethylene and polyvinyl chloride pipe for storm drainage culverts including appurtenances normally installed as a part of these systems. Construction may include surface preparation, trench excavation, shoring, dewatering, lay, align, and join pipe, installation of appurtenances, bedding and backfilling, surface restoration, and other related work.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

References	Title
AASHTO M252	Standard Specification for Corrugated Polyethylene Drainage Tubing
AASHTO M294	Standard Specification for Corrugated Polyethylene Pipe
AASHTO Section 18	Soil Thermoplastic Pipe Interaction Systems
ASTM D1784	Standard Classification System for Specification for PVC and CPVC
ASTM D 2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel Plate Loading
ASTM F794	Standard Specifications for PVC Profile Gravity Sewer Pipe and Fittings – Inside Diameter
ASTM F949	Standard Specification for PVC Corrugated Sewer Pipe with a Smooth Interior and Fitings
ASTM D638	Standard Test Method for Tensile Properties of Plastic
ASTM D1056	Specification for Flexible Cellular Materials - Sponge and Expanded Rubber
ASTM D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

References	Title
ASTM 3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
ASTM D3350	Polyethylene Plastics Pipe and Fittings Material
ASTM D4976	Specification for Polyethylene Plastics Molding and Extrusion Materials
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F667	Standard Specification for Large Diameter Corrugated Polyethylene Tubing and Fittings
ASTM F894	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F2306	Standard Specification for 12 to 60 in. Annular Corrugated Profile Wall Polyethylene Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications
ASTM F2487	Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene and Polypropylene Pipelines
ASTM F2562	Specifications for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage
ASTM F2620	Standard Practice for Heat Fusion Joining of Polyethylene Pipe and fittings
PPI	Handbook of Polyethylene Pipe
PPI TR 33	Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

B. Manufacturer Requirements:
   1. All HDPE pipe shall be from a single manufacturer.
   2. All PVC pipe shall be from a single manufacturer.
   3. Experienced in the design, manufacture, and commercial supplying of the specific material for a minimum period of five (5) years.
   4. Experienced in the design, manufacture, and commercial supplying of the specific size of pipe for a period of one (1) year.
   5. Certify to above minimum experience requirements.

C. Inspection and Testing:
   1. Inspection of the pipe shall be made by the Engineer or other representatives of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Detail drawings which show the type and location of all fittings, joints, and connections to structures and manholes.

PART 2 PRODUCTS

2.01 GENERAL

A. HDPE pipe, which does not conform to ASTM D3350, ASTM D 4976, ASTM F667, ASTM F894, ASTM F2306, or ASTM F2562 or to any other requirement specified herein, shall not be approved for storm sewer, culvert, or sanitary sewer installations.

B. PVC pipe, which do not conform to ASTM D1784, F794, D2412, F949, and F477, ASTM D 4976, ASTM F667, ASTM F894, ASTM F2306, or ASTM F2562 or to any other requirement specified herein, shall not be approved for storm sewer, culvert, or sanitary sewer installations.

2.02 MATERIALS

A. Allowable ASTM Specifications: All material, manufacturing operations, testing, inspection, and making of HDPE or PVC pipe shall conform to the requirements of the appropriate allowable ASTM Standard Specifications, latest revision thereof, listed in Article References.

2.03 PIPE

A. Allowable Pipe diameters for this specification shall be between four (4) inches to sixty (60) inches unless approved by Engineer and Owner.

B. Pipe shall have the nominal dimensions shown with an inside diameter basis and the dimensions and tolerances specified in the appropriate ASTM Specification.

C. Wall Thickness and Class of Pipe:
   1. The wall thickness shall comply with the appropriate ASTM Specification and the class of pipe designated on the Drawings.
   2. HDPE
      a. HDPE pipe and fittings shall have a smooth interior and corrugated exterior. 4 inch through 10 inch shall meet the requirements of AASHTO M252 Type S. 12-inch through 60-inch pipe shall meet the requirements of AASHTO M294 Type S and ASATM F2306. The pipe shall have a full circular cross-section with annular corrugations. Pipe shall be produced to constant internal diameters.
      b. Pipe and fittings shall be made of high-density, high-molecular weight polyethylene material meeting the requirements of cell classification 424420C or higher for 4-inch through 10-inch diameter and 435420C or higher for 12-inch through 60-inch diameter in accordance with ASTM D3350.
      c. Clean rework material generated by the manufacturer's own production may be used so long as the pipe or fittings produced meet all the requirements of this Specification.
   3. PVC
      a. PVC pipe and fittings shall have a smooth interior and corrugated exterior. 4 inch through 36 inch shall meet the requirements of ASTM F949. The pipe shall have a full circular cross-section with annular corrugations. Pipe shall be produced to constant internal diameters.
      b. Pipe shall have minimum cell class 12454 per ASTM D1784.
      c. Clean rework material generated by the manufacturer's own production may be used so long as the pipe or fittings produced meet all the requirements of this Specification.

2.04 FITTINGS AND SPECIALS

A. Elbows and fittings shall be mitered from pipe sections welded together on the interior and exterior at all junctions.

B. The pipe sections forming the miters shall be cut to fit with no gap.

C. Tolerances on the angle of all elbows shall be plus or minus 1 degree.

D. The standard turning radius of elbows shall be 1.5 times the inside diameter. Special turning radii shall be used for special applications.

E. Elbows shall conform to the following requirements:

Angle of Elbow (Degrees)	Number of Miters
0 to 45	1
45 to 90	2

F. Elbows shall be designed to prevent joint rupture resulting from dynamic forces or application of a test pressure of 25 psi.

G. Standards
   1. HDPE fittings shall be ASHTO M252 below 12 inches and ASTM F2306 for larger pipe.
   2. PVC Fittings shall be per ASTM F949 or F794.

2.05 PIPE MARKINGS

A. The following shall be clearly marked on both the interior and exterior surface of the pipe:
   1. Class and size.
   2. Date of manufacture.
   3. Name or trademark of manufacturer.
   4. Deflection angle for bends.

2.06 PIPE JOINING

A. Joints:
   1. Watertight joints shall be accomplished by rubber gasket, in accordance with ASTM D3212.
   2. Gaskets shall be closed-cell synthetic, expanded rubber meeting the requirements of ASTM D1056, Grade 2A2 or made of polyisoprene meeting ASTM F477. Gaskets shall be installed on the connection by the pipe manufacturer.
   3. Lubricant shall have no detrimental effect on the gasket of on the pipe.
   4. Integral bell and spigot gasketed joints shall be designed so that when assembled, the elastomeric gasket, contained in a machined groove on the pipe spigot, is compressed radially in the pipe bell to form a positive seal. The joint shall be designed to avoid displacement of the gasket when installed in accordance with the manufacturer's recommendations.

PART 3 EXECUTION

3.01 PIPE HANDLING AND STORAGE

A. The Contractor shall use care in handling and storage of the pipe. Pipe shall be stored on clean, level ground to prevent undue scratching or gouging of the pipe. If the pipe must be stacked for storage, such stacking shall be done in accordance with the pipe manufacturer's recommendations. The handling of the pipe shall be done in such a manner that it is not damaged by dragging over sharp objects or cut by chokers or lifting equipment.

B. Sections of pipe with cuts, gouges, or scratches on the outside diameter (OD) surface that exceed 10-percent of the wall thickness of the pipe shall be removed completely and the ends of the pipeline rejoined. The inside diameter (ID) surface shall be free of cuts, gouges, and/or scratches.

C. The pipe and pipe coatings shall be inspected by Engineer for damage or defects before being placed in the trench. Damaged or defective pipe shall not be installed.

3.02 INSTALLATION

A. General:
   1. All pipes, which do not meet the requirements of Part 2 of this section, will be rejected and replaced at Contractor's expense.
   2. Contractor shall install storm sewer pipe of the type and diameter that is shown on the Drawings.
   3. Proper equipment, implements, tools, and facilities shall be provided and used by Contractor for safe and convenient installation of the type of pipe being installed.
   4. Unless otherwise specified, the piping system shall be installed in accordance with ASTM D2321 and the manufacturer's recommendations.
   5. Precautions shall be taken to prevent foreign material from entering the pipe before or while it is being placed in the line. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

B. Pipe Fittings:
   1. Pipe fittings shall be laid so as to form a close concentric joint with the adjoining pipe to avoid sudden offsets of the flowline. Pipe sections shall be joined together in accordance with the manufacturer's recommendations.
   2. Pipe fittings and appurtenances shall be carefully lowered into the trench with suitable tools or equipment to prevent damage to the pipe and protective coatings and linings; pipe and accessory materials shall not be dropped or dumped into the trench.

C. Gaskets: No gaskets that show signs of deterioration, such as surface cracking or checking, shall be installed in a pipe joint. The neoprene gaskets used, when the air temperature is ten degrees Fahrenheit (10°F) or lower shall be warmed to temperature of sixty degrees Fahrenheit (60°F) for a period of thirty (30) minutes before being placed on the pipe.

D. Trench Excavation:
   1. Trenches shall be excavated to ensure that sides will be stable under all working conditions. Trench walls or supports shall comply with all local and national standards for safety.

E. Location and Alignment:
   1. Pipe and fittings shall be placed in the trench with the invert conforming to the elevations, slopes, and alignments shown.
   2. Variation from the prescribed grade and alignment shall not exceed one-tenth (0.10) foot, and the rate of departure from, or return to, the established grade or alignment shall be not more than one (1) inch in ten (10) feet, unless approved by Engineer. No deviation from grade shall cause a depression in the sewer invert that could retain fluids or solids. Any pipe which is not in true alignment or which shows undue settlement after laying shall be taken up and re-laid at Contractor's expense.
   3. Lift or roll pipe to protect coating. Do not drag over gravel or rock. Avoid striking rocks or hard objects when lowering into trench.
      a. Pipe on which coatings have been damaged may be rejected at the site of the Work regardless of previous approvals.

4. Obstructions not shown on the Drawings may be encountered during the progress of the WORK. Should such an obstruction require an alteration to the pipe alignment or grade, Engineer will have authority to order a deviation from the Drawings, or Engineer may arrange for the removal, relocation, or reconstruction of any structure which obstructs the pipeline

F. Bedding and Backfill:
   1. Materials used for bedding and backfill shall be as specified in Section 31 23 00 and as shown.
   2. Place materials by methods that will not disturb or damage the pipe. All HDPE pipe shall be at the temperature of the surrounding soil at the time it is backfilled and compacted. Work in and tamp the bedding material in the area under the pipe and up to the spring line before placing and compacting the remainder of the embedment. Blocking under the pipe shall not be permitted.
   3. Use compaction equipment and techniques that are compatible with materials specified and location in the trench. Before using heavy compaction or construction equipment directly over the pipe, place sufficient backfill to prevent damage, excessive deflections, or other disturbances of the pipe.

3.03 TESTING

A. General:
   1. Testing of piping shall be as specified in Section 40 05 01 and this section. In case of conflict, the requirements of this section shall prevail.

B. Acceptance Tests for Gravity and Low-Pressure Pipelines:
   1. Alignment:
      a. Sewer shall be inspected by flashing a light between manholes or by physical passage where space permits.
      b. Contractor shall clean pipe of joint sealant, other dirt, and debris prior to inspection.
      c. Determine from Illumination or Physical Inspection:
         1) Presence of any misaligned, displaced, or broken pipe. 2)
         2) Presence of visible infiltration or other defects.

C. Deflection Testing:
   1. General: Deflection testing shall be performed on the entire length of installed pipe no sooner than 30 days after completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads. Deflection of pipe and fittings in the installed pipeline under external loads shall not exceed the maximum deflection specified.
   2. Maximum installed deflections of flexible pipe shall be five percent (5%) of mean internal diameter.
   3. Pipe exceeding deflection limits, as defined in ASTM D2321, shall be replaced or re-compacted at Contractor's expense.

4. Either of the following devices and procedures may be used to measure deflection:
    a. Pull-Through Deflection Testing: The Contractor shall determine whether the allowable deflection has been exceeded by use of a pull-through device.
        1) Pull-Through Device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided that the device meets the applicable requirements specified in this paragraph, including those for diameter of the device. Ball, cylinder, or circular sections shall conform to the following:
            a) A diameter, or minor diameter as applicable, equal to the average inside diameter of the pipe minus the dimension equivalent of the maximum installed deflection specified. A tolerance of plus 0.5 percent in the diameter of the test device will be permitted.
            b) A homogeneous material throughout, with a density greater than 1.0 as related to water at 39.2 degrees F, and a surface Brinell hardness of not less than 150.
            c) Center bored and through bolted with a 1/4-inch minimum diameter steel shaft having a yield strength of not less than 70,000 pounds per square inch, with eyes or loops at each end for attaching pulling cables.
            d) Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.
        2) Pull-Through Device Procedure: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions as specified.
    b. Deflection Device: The Contractor shall determine whether the allowable deflection has been exceeded by use of a deflection measuring device.
        1) Deflection Measuring Device: This device shall be sensitive to 1.0 percent of the diameter of the pipe being tested and accurate to 1.0 percent of the indicated dimension. The deflection measuring device shall be approved by the Construction Manager prior to use.
        2) Deflection Measuring Device Procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of the maximum allowable specified are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of the allowable, remove pipe which has excessive deflection, replace with new pipe, and completely retest in the same manner and under the same conditions.

END OF SECTION

SECTION 40 06 70

SCHEDULES FOR INSTRUMENTATION OF PROCESS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Instrument List.

B. Related sections:
   1. Section 40 61 13 – Process Control System General Provisions
   2. Section 40 61 21 – Process Control System Testing
   3. Division 40 instrument specifications

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Process Control System General Provisions, submittal requirements: Section 40 61 13.

C. Action Submittal:
   1. Submit updated schedule with field instrumentation submittal to match equipment being provided.

PART 2 NOT USED

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 40 61 13 for requirements.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 40 61 21 for requirements.

B. Maintain a copy of the complete Instrument List with modifications during construction in Excel format. Provide a copy of the latest version to the Engineer or Construction Manager upon request.

3.03 ATTACHMENTS

A. 40 06 70 Attachment A: INSTRUMENT INDEX
   1. Description of headings in Instrument Index.

Instrument Field or Heading	Example	Comment or Description
Tag No. Function Abbreviation	PDIT	See P&ID sheet legend.
Tag No. Area Code	01	See P&ID sheet legend.
Tag No. Loop Identifier	23	See P&ID sheet legend.

Instrument Field or Heading	Example	Comment or Description
Tag No. Suffix 1	A	See P&ID sheet legend.
Tag No. Suffix 2	1	See P&ID sheet legend.
Device Function	Primary sludge Pump 1 Discharge flow	Provides the functional description of the instrument, analyzer, or device.
Size or Connection	4" flange	Provides the application data relative to sizing the instrument; flow tube diameter, probe length, associated pipe sizes, etc. 4-inch, 6-inch flange, 3/4-inch tap
Operating Range	25–65	25 to 65, -10 to 90, etc.
Min Calibration or Setpoint	00	00, 24
Max Calibration Or Deadband	24	20
Units	mgd	mgd, kW, psi, etc.
Signal Type	4-20 mA	4-20 mA, Ethernet, DeviceNet, etc., discrete contact, etc.
Power Requirements	120 V	None, loop, 120-volt, 24-volt, internal battery, etc.
Comments	Class 1 Div 2 Area, Owner-supplied for installation by contractor. Provide grounding ring to match instrument.	Provides the features, interlocks, and information applicable to the instrument, analyzer, or device. Describes special installation instructions, area classifications, modifiers to standard instrument specs, Owner-supplied, existing, accessories, signal surge protection, options, etc.
Device Type	FM	Instruspec type or other name in specification listed below
Specification Number	40 71 00	Specification under which device is provided or specified.
P&ID Number	P-003	P&ID sheet number
Installation Detail Number		Installation detail number if provided.

END OF SECTION

SECTION 40 42 00

INSULATION FOR EXPOSED PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes thermal insulation for exposed piping, related equipment, and appurtenant surfaces.

1.02 RELATED SECTIONS

A. Section 40 05 02 – Detailed Piping Specification Sheets

B. Section 40 50 07 – Pipe Supports and Hangers

C. Section 40 05 07.13 – Seismic Restraints for Piping

D. Section 40 05 45 – Piping System Identification

E. Section 40 41 13.13 – Electric Heat Tracer Tape

1.03 REFERENCES

A. This Section incorporates by reference the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of a listed document, the requirements of this Section prevail.

B. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate

C. ASTM C533 – Calcium Silicate Block and Pipe Thermal Insulation

D. ASTM C534 – Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

E. ASTM C547 – Standard Specification for Mineral Fiber Pipe Insulation

F. ASTM C553 – Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

G. ASTM C592 – Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation

H. ASTM C610 – Expanded Perlite Block and Pipe Thermal Insulation

I. ASTM C795 – Thermal Insulation for Use in Contact with Austenitic Stainless Steel

J. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

K. ASTM E96 – Water Vapor Transmission of Materials

L. FEDSPEC L-P-535E -- Plastic Sheet (Sheeting) “Plastic Strip” Poly (Vinyl Chloride) and Poly (Vinyl Chloride-Vinyl Acetate), Rigid

M. ASTM C1676 – Microporous Thermal Insulation

N. ASTM C1729 – Aluminum Jacketing and Insulation

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

B. Low-temperature range: operating temperature range of -100 to +100 degrees F.

C. Medium-temperature range: operating temperature range of 100 to 800 degrees F.

D. High-temperature range: operating temperature range of 800 to 1200 degrees F.

E. Very-high-temperature range: operating temperature range of 1200 to 1800 degrees F.

F. Jacket: protective outer layer placed over insulation on straight runs of pipe

G. Cover: protective outer layer placed over insulation on valves, strainers, expansion joints, flanges, pipe fittings, couplings, and equipment.

H. Exposed: All area exposures specified in Section 01 61 45 other than buried, submerged, or encased/embedded.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Sequencing: After installation of insulation for pipe and equipment is complete, provide identification as described in Section 40 05 45.

1.06 SUBMITTALS

A. Procedures: Section 01 33 00

B. Action Submittals:
   1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   2. Manufacturer’s descriptive literature, including insulation and jacket thickness, heat transfer coefficient, and methods of installation.
   3. Certification of jacket ratings for water vapor transmission, puncture and stiffness as specified.
   4. ASTM C795 certification, for insulation applied to stainless steel pipe.

C. Informational Submittals:
   1. Samples of each insulation material type and thickness along with typical jackets and covers for pipe, fittings, valves and appurtenances. Provide a full diameter segment for each insulation sample, 6 inches in length.

D. Closeout Submittals:
   1. Warranty Documentation

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00

B. Deliver insulation, jackets and covering to site using methods which do not damage the materials.

C. Deliver insulation materials to site clearly identified as to type and temperature rating.

D. Store insulation materials on site as recommended by the manufacturer to prevent damage or and weathering.

E. Replace damaged or weathered insulation materials with new materials.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Candidate manufacturers and models are listed below. The manufacturer's standard product may require modification to conform to specified requirements.

B. Cellular Elastomeric Tube
   1. Armacell, AP Armaflex
   2. K-Flex, Insul-Tube
   3. Approved Equal

C. Mineral Wool
   1. Roxul, ProRox PS960
   2. Johns Manville, Min-Wool 1200
   3. Owens Corning, Thermafiber Pro Section WR
   4. Approved Equal

D. Fiberglass
   1. Johns Manville, Micro-Lok HP
   2. Owens Corning, FIBERGLAS
   3. Approved Equal

E. Calcium Silicate
   1. Johns Manville, Thermo-1200
   2. Approved Equal

F. Cellular Elastomeric Flexible Blanket
   1. Armacell, AP Armaflex
   2. K-flex, Insul-Sheet

3. Approved Equal

G. Fiberglass Flexible Blanket
   1. Amatex, Amamat
   2. Lewco, E Glass
   3. Approved Equal

H. Mineral Wool Flexible Blanket
   1. Johns Manville, Min-Wool 1200 Pipe and Tank Wrap
   2. Roxul, Enerwrap MA 960
   3. Approved Equal

I. Silica or Ceramic Fiber Flexible Blanket (Very High Temperature Range)
   1. Morgan Thermal Ceramics, Superwool 607 Blanket AC2
   2. Unifrax, Fiberfrax
   3. Harbison Walker, Inswool-HP
   4. Hitco, Refrasil
   5. Approved Equal

J. Expanded Perlite
   1. Johns Manville, Sproule WR-1200
   2. Approved Equal

K. Thin Flexible Blanket
   1. Johns Manville, InsulThin HT
   2. Approved Equal

2.02 INSULATION SERVICE CONDITIONS

A. Insulation Service Types
   1. Insulation service types define the function of the insulation. The extent and location of insulation application is based on the function of the insulation. This Section specifies the following insulation service types: Condensate Control, Personnel Protection, Freeze Protection, and Energy Conservation. Insulation Service Types and insulation materials for piping systems are specified in Piping System Schedules.
   2. Condensate Control is specified for piping that is to be insulated for condensate control. Where Condensate Control is specified for a piping service, furnish insulation for all pipe and pipeline appurtenances with a line size of ½-inch and larger that are located in Indoor Dry or Indoor Wet areas.
   3. Personnel Protection is specified for piping that is to be insulated to protect personnel from injury related to exposure to temperatures above 140 degrees F or below 32 degrees F. Where Personnel Protection is specified for a piping service in the Piping System Schedules, furnish insulation for all pipe and pipeline appurtenances where all of the following conditions are present:
      a. Piping is connected to the discharge or exhaust of equipment (includes equipment and pipeline appurtenances).

b. Equipment, pipe, or pipeline appurtenances are located within 0.0 to 8.0 feet above a floor, stair, landing, or other type of walkway accessible by plant staff, or within 4.0 feet of a guardrail or ladder cage. Pipe, pipeline appurtenances, joints, flanges, valves, and equipment in vaults, utilidors, and other spaces that are not designed for pedestrian access by plant staff are not insulated for Personnel Protection.

4. Freeze Protection is specified for piping that is to be insulated and heat traced to protect against freezing the contents of the pipe. Where Freeze Protection is specified for a piping service in the Piping System Schedules, furnish insulation for all piping to be freeze protected by electric heat trace tape as specified in Section 40 41 13.13. Coordinate electric heat trace tape installation with specified insulation requirements for freeze protection to provide freeze protection for piping as specified in Section 40 41 13.13.
5. Energy Conservation is specified for piping that is to be insulated to conserve energy. Where Energy Conservation is specified for a piping service in the Piping System Schedules, furnish insulation for all pipe and pipeline appurtenances for the entire portion of the piping system that is exposed.

B. General:
1. Provide materials that are new and undamaged.
2. Match specified pipe insulation and jacket/cover material for insulation on valves, strainers, fittings, expansion joints, flanges, and other pipe couplings. Furnish flexible blanket insulation and soft covers if insulation on valves, strainers, fittings, expansion joints, flanges, and other pipe couplings is not available in the same materials as the specified pipe insulation and jacket/cover.
3. Provide rigid insulation and shields at pipe supports for insulated pipe. Match specified jacket/cover material for pipe shields at pipe supports.
4. Provide insulating and sealing materials, including cements, coverings, etc., that do not contain asbestos, mercury, or lead.
5. When covering stainless steel pipe, pipeline appurtenances, or equipment, use insulation that complies with ASTM C795..
6. Flame spread classification for insulation materials is not to exceed 25 when tested in accordance with ASTM E84.
7. Use fibrous loose fill insulation for joint filler around insulated expansion joints.

C. Fiberglass Flexible Blanket: Flexible fiberglass blanket insulation designed for continuous 1200 degree F service. 8.0 pounds per cubic foot density, minimum. Long fiber, random orientation, needled.

D. Mineral Wool Flexible Blanket: Flexible mineral wool blanket insulation designed for continuous 1200 degree F service.

E. Silica or Ceramic Fiber Flexible Blanket: High purity alumina and silica non-asbestos white ceramic fiber insulation designed for continuous 1800 degree F service.

F. Aluminum Insulation Jackets/Covers
1. Aluminum jackets and covers constructed of smooth finish aluminum sheet conforming to ASTM B209, alloy 3003, or 3105 temper H14, with integral vapor barrier.

2. Pipe Insulation Jacket thickness per ASTM C1729, as follows.

Outer Insulation Diameter (inches)	Aluminum jacket thickness, rigid insulation (inch)	Aluminum jacket thickness, flexible and semi-rigid insulation (inch)
≤ 8	0.016	0.016
8 thru 11	0.016	0.020
11 thru 24	0.016	0.024
24 thru 36	0.020	0.032
≥ 36	0.024	0.040

3. Furnish 0.030 inch, minimum thickness, for aluminum insulation covers at valves, strainers, fittings, expansion joints, flanges, and other pipe couplings.
4. Aluminum or stainless steel sheet metal screws.
5. Jackets secured with 0.020 inch thick by ¾ inch wide Type 304 stainless steel expansion bands.
6. Flashing includes aluminum caps, sealant and reinforcing.
7. Provide aluminum caps, 20 gauge. Cut to completely cover the insulation.
8. Provide sealants as recommended by the insulation manufacturer.
9. Provide wire mesh reinforcement or nylon fabric reinforcement in sealant at jacket and cover joints. Reinforcement material as recommended by the insulation manufacturer.

G. PVC Insulation Jackets and Covers
1. One piece PVC covers and jackets. 20 mil thickness, minimum.
2. Pre-molded polyvinylchloride conforming to FEDSPEC L-P-535E, Composition A, Type II, Grade E4.

H. Non-combustible Fabric Cover
1. Custom fit reusable covers. Sewn or stapled covers encapsulating insulation with stainless steel staples/hog rings. Close fit to the piping, pipeline appurtenance, or equipment housing.
2. Fabricated from 32 ounce TFE-coated or silicone coated fiberglass cloth with concealed/interior stitching, staples or hog rings (not exposed). For flexible blanket insulation installed for High-Temperature and Very High-Temperature Range applications, eliminate non-combustible fabric material on hot face of covers and provide stainless steel wire mesh on hot face of covers.
3. Fabric rated for continuous exposure to the temperature range of the insulation (Low, Medium, High, or Very High Temperature Range).
4. Secured in place with stainless steel lacing hooks, lock washers, and lacing wire.
5. Stitched or quilted to prevent consolidation, shifting, or settlement of insulation when subjected to vibration.

PART 3 EXECUTION

3.01 PREPARATION

A. Apply insulation over clean, dry surfaces.

B. Ensure insulation is dry before and during application.

C. Do not apply protective pipe coatings to outside surface of insulation jackets or covers.

D. Do not paint PVC, aluminum, or fabric covers.

E. Do not install insulation or jackets/covers before piping and equipment has been tested and approved. Thermal shields at pipe hangers and supports may be installed prior to testing.

F. Provide thermal pipe hanger shields at pipe supports and bracing as specified on the Drawings, Details, Section 40 05 07 and Section 40 05 07.13.

3.02 INSTALLATION

A. General
   1. Where insulation thickness exceeds 3 inches, double layer insulation must be provided. Install double layer insulation with staggered section joints.
   2. Supply insulated thermal pipe hanger shields and install during pipe support installation. Where insulated thermal pipe hanger shields are used, apply the following to all butt joints:
      a. For pipe insulation with a medium, high, or very high Operating Temperature Range, apply 3 inch wide vapor barrier tape or band over the butt joints.
      b. For pipe with a low Operating Temperature Range, apply a wet coat of vapor barrier lap cement on all butt joints and seal the joints with a minimum 3 inch wide vapor barrier tape or band.

B. Protect insulation and jackets from crushing, denting, and similar damage during construction. Do not penetrate or otherwise damage vapor barriers. Remove any insulation, jacket, and vapor barriers damaged during construction and install new material.

C. Provide flashing at joints between insulation jackets, between insulation jackets and insulation covers, and at endcaps. Provide flashing around flange sets, pipe couplings/connections, and joint fittings. Allow adequate clearance between insulation rings, jackets and the joint connection for the removal and reinstallation of hardware during inspection and maintenance activities.

D. Piping Insulation
   1. Install uninterrupted (continuous) insulation as indicated for the specified Insulation Service Conditions (Condensation Control, Energy Conservation, Personnel Protection, or Freeze Protection). Insulate over pipe and all in-line devices such as valves, fittings, flanges, couplings, strainers and other piping appurtenances. Butt insulation firmly together and provide jacket laps and joint strips with lap adhesive. Provide a minimum of 2 inches of lap length. Install jackets with their seams located on the underside of pipe.
   2. Covers overlap the adjoining pipe insulation and jackets.
   3. Install covers with their seams located on the underside of valves, fittings, flanges, couplings, strainers and other piping appurtenances.

4. Low Operating Temperature Range
    a. Seal off ends of pipe insulation with a vapor barrier coating.
    b. Seal covers at edges with vapor barrier adhesive. Secure the ends of covers with vinyl tape. Overlap the jacket and the cover at least one inch with vinyl tape. Do not penetrate vapor barrier.
5. Medium, High, and Very High Operating Temperature Range
    a. Seal ends of insulation with end joint strips and use waterproof adhesive to hold them in place.
    b. Mechanically secure covers using corrosion-resistant tacks pushed into the overlapping throat joint.
6. Insulation for Outdoor Piping
    a. Where insulated pipe emerges from soil, concrete or asphalt terminate insulation for exposed pipe at the interface with insulation for buried pipe. If buried pipe is not insulated, extend insulation to within an inch above the finished surface. Do not push insulation into contact with soil, finished concrete, or asphalt surface.
    b. Provide heat tracing as specified in Section 40 41 13.13. Install insulation over heat tracing according to the specifications of the heat trace tape and insulation manufacturers.

E. Mechanical Equipment Insulation
1. Unless otherwise specified in this Section, fit insulation to the contours of equipment and secure it with 1/2 by 0.015 inch stainless steel bands. Weld pins or stick clips with washers may be used for flat surfaces and spaced a maximum 18 inches apart. Stagger joints and fill voids with insulating cement.
2. Overlap ends of blanket segments to prevent gaps and voids when the piping and equipment are heated.
3. Secure blankets snugly under nuts and bolt heads to assure complete coverage during operation and to prevent vibration-induced gaps or voids.
4. Secure blankets in strict accordance with the manufacturer's instructions.

F. Flashing
1. Provide flashing at jacket penetrations and terminations. Provide clearance for flashing between insulation system and piping supports.
2. Form aluminum caps to fit over the adjacent jacketing and to completely cover coated insulation. Hold cap in place with a jacket strap.

END OF SECTION

SECTION 40 61 13

PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies general requirements applicable to Sections 40 60 00 through 40 79 99 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a single Systems Integrator (SI) meeting the qualifications section of this specification.

B. System overview. Detailed requirements are in individual related specification sections.
   1. Field Instrumentation:
      a. New field instruments.
   2. Process Control Hardware:
      a. Expansion of Owner's existing control system.
      b. Field controllers use programmable logic controllers (PLC).
      c. New control panels.
   3. Process Control Software, Programming, and Integration:
      a. Expansion of Owner's existing control system.
      b. Integrated hardware and software across controllers and operator interface systems from separate manufacturers.
      c. All integration shall be provided by IS. Programming of Contractor-supplied PLCs and SCADA/HMI shall be provided by others.
      d. Coordinated programming and testing responsibilities between supplier and Owner.
      e. Integration with packaged system controls in other sections.
      f. Integration with existing plant security system, andplant network and communication system.
   4. Communications and Networking
      a. Interface to and expansion of existing Owner networks.
      b. Hardwired fiber-optic and copper communications systems.

1.02 RELATED SECTIONS:

A. The requirements of this section are applicable to work specified in Sections 40 60 00 through [40 79 99] of these specifications.

B. Section 40 06 70 – Schedules for Instrumentation of Process Systems.

C. Division 26 - Electrical

1.03 REFERENCES

A. Reference Standards:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
   2. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
   3. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
   4. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
IEEE 100	Standard Dictionary of Electrical and Electronics Terms
ISA 5.4	Instrument Loop Diagrams
ISA 20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
ISA 51.1	Process Instrumentation Terminology
ISA TR20.00.01	Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations
NFPA 70	National Electrical Code (NEC)
NEMA ICS 1	General Standards for Industrial Control and Systems

1.04 DEFINITIONS

A. Abbreviations:
   1. dBm: decibel-milliwatts
   2. DCS: distributed control system
   3. DCU: distributed control unit, or digital control unit.
   4. HIM: human interface module
   5. HMI: human-machine interface
   6. OIT: operator interface terminal
   7. PCS: plant control system
   8. PICS: Process and Instrumentation Control System
   9. PLC: programmable logic controller
   10. RTU: remote terminal unit
   11. SCADA: supervisory control and data acquisition
   12. SI: Systems Integrator

B. Definitions General:

1. General: Definitions of terminology related to Instrumentation and Industrial Electronic Systems used in the specifications as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.
2. Data sheets: Data sheets refer to ISA 20 or ISA TR20.00.01, as referenced within ISA-20-1981 specification.
3. Two-wire transmitter: A transducer that derives operating power supply from the signal transmission circuit and requires no separate power supply connections. A two-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a 24-volt direct current (VDC) driving potential and a maximum circuit resistance of 600 ohms.
4. Four-wire transmitter: A transducer that derives operating power from separate power supply connections. A four-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a maximum circuit resistance of 600 ohms. Four-wire transmitters typically require 120-volt alternating current (VAC) or 24VDC input power supply.
5. Galvanic isolation: An electrical node having no direct current path to another electrical node. Galvanic isolation refers to a device with electrical inputs and/or outputs that are isolated from ground, the device case, the process fluid, and separate power supply terminals. Inputs and/or outputs may be externally grounded without affecting the characteristics of the devices or providing a path for circulation of ground currents.
6. Panel: An instrument support system that may be a flat surface, partial enclosure, or complete enclosure for instruments and other devices used in process control systems including consoles, cabinets, and racks. Panels provide mechanical protection, electrical isolation, and environmental protection from dust, dirt, moisture, and chemical contaminants that may be present in the atmosphere.
7. Systems Integrator: A firm engaged in the business of detailed control system design and engineering, instrumentation component purchase, system and panel assembly, control device programming, and implementing of the specified process control and industrial automation systems.
8. Impulse line: A small-gauge pipe that is used to connect a point in a pipe in which the pressure is measured at an instrument. In flow measurement using a primary device such as an orifice plate, nozzle or Venturi meter, impulse lines are used to connect upstream and downstream (or throat) points of the meter to a secondary device for measuring the differential pressure.

C. Definitions—Signal Types:

1. Analog, low level: Signal with full output level of 100 millivolts or less including thermocouples and resistance temperature detectors.
2. Analog, high level: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4 to 20 mA transmission.
3. Audio signals, high level: Audio signals exceeding plus 4 dBm, including loudspeaker circuits.
4. Digital code: Coded information from the output of an analog-to-digital converter or digital transmission terminal.
5. Discrete control or events: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits.

6. Discrete control or events, low voltage: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits operating at less than 30 volts and 250 milliamperes.
7. Modulated signals: Signals from modems or low-level audio signals. Normal signal level: plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
8. Pulse frequency: Counting pulses emitted from speed or flow transmitters.
9. Radio frequency (RF) signals: Continuous wave alternating current signals with fundamental frequency greater in a range of 310 kilohertz to 300 gigahertz.

D. Definition—Drawing Types:
   1. Elementary or schematic diagram:
      a. Use graphic symbols to indicate the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing of the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
      b. Indicate connections to internal and external components connected to the panel. Note which devices are external to the panel.
      c. Depicted in ladder logic format.
      d. Indicates contact arrangement of internal and external devices such that circuits are complete and match equipment furnished.
      e. Indicates equipment designations/tag numbers to match contract drawings and P&IDs.
   2. Block diagram: A diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
   3. Network block diagram:
      a. A diagram of the overall control system, containing annotated boxes showing the primary network components (controllers, hubs, routers, switches, computers, displays).
      b. Include annotated interconnecting lines showing the system communication media and communication protocols.
      c. Indicate manufacturer and model of the primary network components and software.
      d. Indicates functions performed by each device (e.g., Historical Data Server, Field controller, Database Server, Operator workstation, etc.)
   4. Connection diagram:
      a. Purpose is to show wiring requirements between internal panel components.
      b. Show components of a control panel in an arrangement similar to the actual panel layout.
      c. Indicate internal wiring between components.
      d. Show terminal blocks used for internal wiring and field wiring, with identification as such.
      e. Indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.
   5. Interconnection diagram:
      a. Purpose is to show wiring requirements between panels, standalone devices, components, and instruments.

b. Indicate wire numbers, cable numbers, raceway numbers, terminal box numbers, terminal block numbers, panel numbers, and field device tag numbers.
c. Show external connections between terminals of equipment and outside points, such as motors and auxiliary devices.
d. Indicate references to connection diagrams that interface to the interconnection diagrams.
e. Interconnection diagrams are to be of the continuous line type. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
f. Show termination of each cable. Clearly mark each termination point. Show each wire's identification as actually installed. The wire identification for each end of the same wire shall be identical. Identify devices and equipment.
g. Depict terminal blocks as actually installed and identified in the equipment with individual terminal identification.
h. Indicate external jumpers, shielding, and grounding terminations.
i. Indicate polarities for signal and DC circuit.
j. Depict spare wires and cables installed or slated for installation.

6. Arrangement, layout, or outline drawings:
   a. Show the physical space and mounting requirements of a piece of equipment.
   b. Indicate ventilation requirements and space provided for connections or the location to which connections are to be made.
   c. Indicate clearance requirements for ventilation and access.
   d. Show the dimensioned external and interior control panel views with components and Bill of Material.
7. Loop diagrams:
   a. Prepared per ISA 5.4 – Loop Diagrams using the sample Loop Diagrams attached to this section.
   b. Show device element wiring of the system. Indicate device terminations, with terminal numbers.
   c. Show circuits for hardwired device interlocks.
   d. Show circuit cable and wire cable numbers, signal polarities, and terminal block numbers.
   e. Show connection to power supplies. Include alternating current (AC) and direct current (DC) power supplies and circuit information for instruments furnished under this contract.
   f. Indicate controller or I/O card address/node, rack, slot, and point wiring terminals.
   g. Show power supplies for signal loops. Indicate in which panel components reside and power originates with circuit numbering/name. Where new/modified loops connect to an existing power supply, show the existing power supply name, location, and circuit.
   h. Indicate surge protection type, manufacturer, and model number (i.e., types include floating ground reference or grounded reference).
   i. Show new and modified terminal blocks with numbering in new and existing panels.
   j. Indicate signal loop grounding terminations.

k. Indicate loop numbers, wire numbers, and cable numbers used in field wiring and panel wiring.

l. Indicate field element being controlled or monitored (i.e., normally open contact from relay CR17, or FIT 365).

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the process and instrumentation control system for proper operation with related equipment and systems specified in other Divisions.
2. Integrate equipment in conformance with the drawings, specifications, and recommendations of the equipment manufacturer and the related processes equipment manufacturers.
3. Obtain manufacturer's technical information for items of equipment not provided with, but connected to, the control system. Provide the necessary coordination and components for correct signal interfaces between equipment and the control system.
4. Coordinate interface requirements and schedule with other project subcontractors and equipment suppliers.
5. Present to the Construction Manager conflicts between the plans, specifications, manufacturer/vendor drawings, and installation instructions, etc. for resolution before proceeding.

B. Pre-submittal conference:

1. Schedule a pre-submittal conference with the Contractor, Systems Integrator, Owner, Engineer, and Construction Manager within 30 calendar days after Contract award to discuss the work, equipment, and submittal format, and to establish the framework for project coordination and communication.
2. Provide the following materials 10 days prior to the conference:
   a. Proposed Systems Integrator that will meet the qualifications requirements of this section.
   b. Indicate full conformance with the specification sections covered by this section with a contract deviations request. Requested contract deviations to reference and to be attached to the applicable contract specifications and drawings. Provide justification for requested deviations.
   c. Proposed "equal" products that differ from specified manufacturers/models with comparative listing of the published specifications for the specified item and the proposed item.
   d. Project schedule with deliverables and milestones through project completion.
   e. Sample submittal drawings, as specified to be provided for this project. Samples can be a copy from a previous project provided that represents the format being proposed for this project.
      1) Control system block diagram.
      2) Documented controller and operator interface program.
      3) Control panel schematic diagram.
      4) Interconnection diagram.
      5) Analog and discrete loop diagrams.
      6) Control panel arrangement drawing.

3. The pre-submittal conference will not replace the Product and Shop Drawing Submittal review process.

1.06 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00.
   2. This article indicates general requirements applicable to all PICS submittals. Additional information to be submitted with each section will be listed under Action Submittals or Closeout Submittals in this and each related section.
      a. Submit all information for sections covered by a submittal as a complete package in one submittal. Partial submittals of a section from multiple vendors showing contractor's division of equipment, labor, or portions of the work are not acceptable.
      b. Include a table of contents in each submittal divided by specification section and content of each section such as drawings and components. Clearly indicate the article or paragraph to which each table of content item applies.
      c. Related sections indicate additional detail for each submittal.
      d. Bookmark PDF submittals to match the table of contents of each submittal. Submitted information is to conform to the following:
         1) Shop Drawings: Prepare drawings in .pdf format with borders and title blocks identifying the project, system, revisions to the drawing, and type of drawing. Include a date and description for each revision of a drawing including the date and description of the revisions. Drawing prints shall be 11" by 17" with a minimum lettering size of 1/8". Where directed, Contractor shall generate drawings using Owner-furnished drawing borders and title blocks, and in adherence to Owner's latest standards.
         2) Product Literature: Provide manufacturer's specifications, data sheets, and catalog literature for the equipment and components that clearly and unambiguously show what is being provided and that it meets the requirements specified. Indicate provided and available options, materials of construction, environmental characteristics, electrical characteristics, and connection requirements. Include only applicable information.
      e. Conformance with Contract Documents:
         1) Provide a copy of sections applicable to the submittal group with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
         2) Check-marks (✓) shall be used to denote full compliance with a paragraph as a whole. Underline deviations and denote them with a number in the margin to the right of the identified paragraph. Paragraph portions not underlined signify specification compliance. Include a detailed, written justification for each deviation. Show conformance with all paragraphs in a section. Failure to include a copy of the marked-up specification sections and justification(s) for requested deviations is cause for rejection of the entire submittal with no further consideration.

3) Mark a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings "no changes required." Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review. Contract drawings would include the following:
    a) Network system block diagrams
    b) Cabinet and panel arrangement drawings
    c) Control single-line diagrams
    d) Process and instrumentation diagrams
    e) Instrument installation details
4) Show conformance across suppliers and vendors in one submittal. Partial submittals from multiple vendors showing contractor's division of labor or portions of the work are not acceptable.
5) Provide a detailed written request and explanation for each deviation. Failure to include a copy of the marked-up specification sections and drawings, along with justification(s) for requested deviations to the contract requirements, with the submittal, is cause for rejection of the entire submittal with no further consideration.

B. Closeout submittal general requirements.
    1. Procedures: Section 01 78 23.
    2. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.
    3. Include the following in each operation and maintenance manual:
        a. Final reviewed submittals, including revised as-built record drawings.
        b. Manufacturer's operation and maintenance instructions, edited for this project.
        c. Written record of menu configuration, jumpers, switch settings, and other configurable parameters for each instrument.
        d. Final hardware and software configurations for Contractor-supplied equipment in the native format. Include a comprehensive report print-out from each Contractor- and vendor-supplied CPU in full color. Provide in .pdf format on electronic media, including a hard copy.
        e. Final network equipment software configurations.
    4. Markup of existing O&M documentation that show modifications to existing panels, communications, and loops/wiring.
    5. Maintenance Material Submittals
        a. Provide one listing of spare parts that is divided by specification section.
        b. Include list prices for spare parts, expendable supplies, and tools.
        c. Indicate spare parts packaging and storage methods.
        d. Indicate spare parts or components that could be deleted or reduced based on manufacturer's recommendations.

e. Indicate where manufacturer's recommendations exceed the spare parts specified.

f. Obtain spare parts from the equipment manufacturer. Do not provide third-party equivalent replacements.

g. Packaging, Testing, and Storage:

1) Provide protective toolboxes for special tools.

2) Test spare boards, circuit cards, power supplies, and similar spare electronic assemblies on site prior to acceptance.

3) Carefully repackage operable parts. Immediately remove inoperable parts from the site and order replacement parts. Test replacement parts prior to acceptance.

4) Package spare parts for protection against dirt and moisture. Label each package as to its contents with a description and part number.

5) Do not place spare parts for different equipment items in the same package.

C. Action Submittals

1. Quality Assurance (within 30 days of contract Notice to Proceed):

a. Systems Integrator qualifications per paragraph 1.08, Quality Assurance.

b. Project personnel qualifications per paragraph 1.08, Quality Assurance.

2. Interconnection Diagrams per paragraph 1.02.

a. Between all Contractor-supplied, vendor-supplied, and System Integrator-provided equipment.]

b. Between all System Integrator-provided equipment and all other connected equipment. Include terminal numbers for all other connected equipment.

D. Closeout Submittals

1. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.

1.07 QUALITY ASSURANCE

A. All work covered by Sections 40 60 00 through 40 79 99 shall be the responsibility of a single SI as defined within this article.

B. The instrumentation and control system functions are shown on the drawings and specified in subsequent sections of Division 40. The SI drawings and integration practices shall be as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.

C. Demonstrate the overall system performance to the Owner for acceptance.

D. SI qualifications:

1. The following Systems Integrators are pre-qualified to perform the work specified in Division 40 without the need to provide Evidence of Experience:

a. (Need input from SLC DPU and CCWTP for qualified Sis)

b. Only the firms above will be allowed to provide this work.

2. Evidence of Experience—Company specializing in the products and work of this section and related sections:
    a. Minimum of 10 years of documented experience with the equipment specified as well as overall systems responsibility for systems of similar size and complexity.
    b. Experience in performing three similar successful projects (equipment type, software type, SI responsibilities, complexity, and dollar value of work performed by SI) in the last 5 years. At least one project currently in progress or completed within the last 2 years.
    c. End-user satisfaction of projects in the past 3 to 5 years based on end-user interviews by the Owner or Engineer. Submit project descriptions of projects completed within the past 5 years with contact names, addresses, and telephone numbers from the project Owner, General Contractor, and Principal Design Firm.
    d. Panel fabrication and staging facilities adequate to provide services for this project. Demonstrate by including the following:
        1) Minimum 10,000 square feet of dedicated space for panel fabrication and testing.
        2) Panel shop shall be UL 508/508A recognized to produce panels to UL 508/508A and UL 698 standards and labeling.
    e. Financial resources available and projected for successful completion of this project. Submit financial data for SI division when subsidiary to a parent corporation. Include 2 years of financial data:
        1) Financial statement.
        2) Balance sheet.
        3) Dun & Bradstreet Report.

E. SI Personnel Qualifications: Provide qualified personnel to complete the work specified for this project. Demonstrate by including the following:
    1. Organization chart and resumes for proposed project personnel showing experience for the proposed roles on this project.
    2. Training and certification information. Completion of the following training courses or appropriate portions thereof or possession of the following certifications included with the Systems Integrator's personnel experience requirements described above:
        a. Project manager: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or Project Management Professional (PMP) certification.
        b. Systems engineer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program as certified by ISA.
        c. Programmer: Certified by the software/hardware manufacturer for the software and hardware being used on the project, or Control System Engineer (CSE), or Professional Engineer (PE) registration.
        d. Field instrument technician: Certified Control Systems Technician (CCST) registration or completion of the relevant core courses in the Technical Skills Training program as certified by ISA.

1.08 ENVIRONMENTAL CONDITIONS

A. Ambient conditions: Per Section 01 11 80

B. Corrosive locations: Per Division 26.

C. Hazardous (Classified) areas: Per contract drawings.

D. Seismic:
   1. Brace equipment and supports per Structural Drawings.

PART 2 PRODUCTS

2.01 EQUIPMENT/MATERIALS

A. General requirements:
   1. New.
   2. Free from defects.
   3. Rated for the installed environment.

B. Similar control system components, instrument, instrument accessory, and devices used throughout the work shall be manufactured by one firm, where possible.

C. The components, modules, devices, and control system equipment shall be recognized industrial-quality products. Recognized commercial- or office-grade products are prohibited.

D. Identification of Listed Products: Provide process measurement devices listed and labeled for the purpose for which they are to be used and the installation environment, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Factory Mutual (FM). Independent testing laboratory need be acceptable to the inspection authority having jurisdiction.

E. Use electronic equipment of solid-state construction with printed or etched circuit boards of glass epoxy of sufficient thickness to prevent warping.

F. Printed circuit boards in field-mounted equipment are to be coated with 2 mils of conformal coating in compliance with MILSPEC MIL-I-46058C.

G. Equipment supports: shall be 316L stainless steel, as shown, or as specified.

2.02 SOFTWARE

A. Software packages are to be latest versions available or compatible with existing software currently in use, as specified in Section 40 68 13.

2.03 ENCLOSURES

A. Table A specifies the instrument and control panel enclosure material and minimum NEMA rating for the location and application where not identified in other specification sections.

TABLE A

Location	Enclosure Material and NEMA Rating
Indoor: architecturally finished area	NEMA 12: mild steel
Indoor: electrical room	NEMA 12: mild steel
Indoor: process areas	NEMA 4X: compatible with environment
Indoor: corrosive area	NEMA 4X: compatible with environment
Outdoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: non-corrosive areas	NEMA 4X: 316 stainless steel
Corrosive area (hypochlorite)	NEMA 4X: non-metallic
Hazardous area	NEMA 7: galvanized malleable iron or aluminum or NEMA 4X and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.
Hazardous and corrosive area	NEMA 7: iron or aluminum with factory-applied corrosion-resistant coating or NEMA 4X and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.

2.04 NAMEPLATES

A. Provide nameplates for field-mounted instrument, analyzer, or equipment covered by this section with the following requirements:
   1. Include the equipment or instrument loop title and the instrument or equipment tag number, where nameplate engraving is not specified or shown.
   2. Machine engraved with black lettering on white phenolic with 5/32-inch-high lettering, as minimum, unless otherwise specified or shown.

B. Nameplate wording may be changed without additional cost or time if changes are made prior to commencement of engraving.

C. Attach nameplates to support hardware with a minimum of two self-tapping type 316 stainless steel screws in a readily visible location so the nameplate will remain to identify the service when the device is removed. Attach field instrument nameplates with braided stainless steel straps where not stand-mounted.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements prior to fabrication.

3.02 INSTALLATION

A. General:
   1. Install equipment in locations that are accessible for operation and maintenance services.
   2. Installation, calibration, settings, and testing procedures are specified in Section 40 61 13, Section 40 06 70, and subsequent sections of Divisions 26 and 40.
   3. Equipment and instruments located in classified areas shall be installed in accordance with the manufacturer's requirements for installation; including classified areas. The installation shall meet the requirements for protection techniques or methods required by the NEC.

B. Field Equipment:
   1. Provide equipment with ports and adjustable items accessible for in-place testing and calibration. Install equipment between 48 inches and 60 inches above the floor or permanent work platform. Equipment shall be mounted to avoid shock or vibration that may impair operation. Equipment shall be mounted for unobstructed access and walkways. Equipment support systems shall not be attached to handrails, process piping or mechanical equipment.
   2. Instruments and cabinets supported by concrete walls shall be spaced 5/8 inch by framing channel between instrument or cabinet and wall. Block wall shall have additional installation supports, as required, to avoid damage to the wall. Equipment support material shall be, as shown or specified.
   3. Support systems including panels shall be designed in accordance with Section 01 73 23 to prevent deformation greater than 1/8 inch in any direction under the attached equipment load and under an external load of 200 pounds.
   4. In wet or outdoor areas, conduit penetrations for connection shall be made through the bottom (preferred) or side of enclosures to minimize water entry from around or from inside of conduits. Provide conduit hubs for connections and waterproof mastic for moisture sealant.

C. Electrical Power Connections:
   1. Equipment electric power devices and wiring shall comply with Division 26.
   2. Provide power disconnect switches for all instruments, equipment, and panels within sight of equipment and labeled to indicate the specific equipment served and the power source location. "Within sight of" is defined as having an unobstructed view from the equipment served and within 50 feet of the equipment served.
   3. Equipment power disconnect switches shall be mounted between 36 inches and 72 inches above the floor or permanent work platform. Where equipment location requirements cannot be met by a single disconnect switch, provide two disconnect switches: one at the equipment and one at the work platform.
   4. Provide a surge arrestor on each 120 VAC disconnect switch serving equipment located outdoors.

D. Signal Connections:
   1. Equipment electric signal connections shall be made on terminal blocks or by locking plug and receptacle assemblies. Flexible cable, receptacle and plug assemblies shall be used where shown or specified.

2. Jacketed flexible conduit shall be used between equipment and rigid raceway systems. Flexible cable assemblies may be used where plug and receptacle assemblies are provided and the installation is not subject to mechanical damage in normal use. The length of flexible conduit or cord assemblies shall not exceed 2 feet except where sufficient length is required to allow withdrawal of instruments for maintenance or calibration without disconnection of conduit or cord assemblies.

3.03 INTEGRATION WITH OTHER SYSTEMS:

A. Integrate new equipment with the existing control system network as shown on the project drawings.

3.04 FIELD QUALITY CONTROL

A. Delivery Inspection:
   1. Notify the Owner's Representative upon arrival of material or equipment to be incorporated into the work. Remove protective covers or otherwise provide access in order that the Owner's Representative may inspect such items.
   2. Provide receipt verification prior to installation. Check:
      a. Equipment received is equipment ordered.
      b. Equipment meets specified requirements and approved submittals.
      c. Equipment has correct manufacturer manuals.
      d. Equipment has been factory calibrated, bench calibrated or has method for field calibration.

B. Inspection and Installed Tests:
   1. Refer to Section 40 61 21.

3.05 CLEANING

A. Execute final cleaning prior to final project assessment.

B. Clean surfaces exposed to view, remove temporary labels, stains, and foreign substances.

C. Replace filters of operating equipment.

D. Remove waste and surplus materials, rubbish, and construction facilities from site.

3.06 MAINTENANCE

A. Refer to contract documents regarding maintenance scope, period, and duration.

PART 4 ATTACHMENTS

A. Attachment A – Sample Loop Drawings

END OF SECTION

Item	Area	Loop Number	Tag	Description	P&ID	Specification	INSTRUSPEC Symbol	Instrument Type	Power Requirement	Size	Calibration Range	Set Point	Installation Detail	Equipment Vendor Provided	Application Notes
	1	00007	LSL00007	INFILTRATION GALLERY LOW LEVEL SWITCH	1-PI-01	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC	1" MNPT	1-50 FT	N/A		NO	
	1	00007	LSM00007	INFILTRATION GALLERY MID LEVEL SWITCH	1-PI-01	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	1	00007	LSH00007	INFILTRATION GALLERY HIGH LEVEL SWITCH	1-PI-01	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	3	00011	PIT00011	SODIUM HYPOCHLORITE TRANSFER PUMP DISCHARGE PRESSURE	03-PI-01	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00010	LIT00010	SODIUM HYPOCHLORITE DAY TANK 1 LEVEL TRANSMITTER	03-PI-01	40 72 00	LRM	RADAR LEVEL TRANSMITTER	LOOP	1.5" MNPT	1 - 26 FT	N/A			
	3	00010	LSHH00010	SODIUM HYPOCHLORITE DAY TANK 1 HIGH HIGH LEVEL SWITCH	03-PI-01	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	3	00010	LSLL00010	SODIUM HYPOCHLORITE DAY TANK 1 LOW LOW LEVEL SWITCH	03-PI-01	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	3	00013	PIT00013	SODIUM HYPOCHLORITE RECIRCULATION LINE PRESSURE	03-PI-01	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00021	PIT00021	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 DISCHARGE PRESSURE	03-PI-01	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00031	PIT00031	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 DISCHARGE PRESSURE	03-PI-01	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00020	LIT00020	SODIUM HYPOCHLORITE DAY TANK 2 LEVEL TRANSMITTER	03-PI-02	40 72 00	LRM	RADAR LEVEL TRANSMITTER	LOOP	1.5" MNPT	1 - 26 FT	N/A			
	3	00020	LSHH00020	SODIUM HYPOCHLORITE DAY TANK 2 HIGH HIGH LEVEL SWITCH	03-PI-02	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	3	00020	LSLL00020	SODIUM HYPOCHLORITE DAY TANK 2 LOW LOW LEVEL SWITCH	03-PI-02	40 72 00	LFS	FLOAT SWITCH, FREE FLOATING	120VAC						
	3	00023	PIT00023	SODIUM HYPOCHLORITE RECIRCULATION LINE PRESSURE	03-PI-02	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00041	PIT00041	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 DISCHARGE PRESSURE	03-PI-02	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	3	00051	PIT00051	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 DISCHARGE PRESSURE	03-PI-02	40 73 00	PAT	ABSOLUTE PRESSURE TRANSMITTER	LOOP						
	35	0001A	PI00012	RAW WATER SAMPLE PUMP DISCHARGE PRESSURE GAUGE	35-PI-01	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	0-100 PSI	N/A		NO	
	35	00012	PSL00012	SAMPLE PUMP HIGH PRESSURE SWITCH	35-PI-01	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	0-100 PSI	25 PSI		YES	
	35	00012	FI00012	INFILTRATION GALLERY FLOW	35-PI-01	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	8" FLANGED	0-1600 GPM	N/A		NO	
	35	00011-1	FI00011-1	RCW FLOW	35-PI-01	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	12" FLANGED	0-3500 GPM	N/A		NO	
	35	00012	PI00012	FMX PUMPS SEAL WATER PRESSURE GAUGE	35-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00012	PSL00012	FMX PUMPS SEAL WATER LOW PRESSURE SWITCH	35-PI-02	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	TBD	N/A		NO	
	35	0001A	PSH0001A	FMX PUMPS SUCTION HIGH PRESSURE SWITCH	35-PI-02	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	TBD	N/A		NO	
	35	1001A	PI1001A	FMX PUMP 1 SUCTION PRESSURE GAUGE	35-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	2001A	PI2001A	FMX PUMP 2 SUCTION PRESSURE GAUGE	35-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	10011	AE10011	FMX PUMP 1 CONDUCTIVITY	35-PI-02	40 75 00	AC	CONDUCTIVITY ANALYZER							
	35	20011	AE20011	FMX PUMP 2 CONDUCTIVITY	35-PI-02	40 75 00	AC	CONDUCTIVITY ANALYZER							
	35	00013	PSH00013	FMX PUMPS HIGH DISCHARGE PRESSURE SWITCH	35-PI-02	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	00013	PI00013	FMX PUMPS DISCHARGE PRESSURE GAUGE	35-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00020	FIT00020	FMX PUMP DISCHARGE FLOW	35-PI-03	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	4"	TBD	N/A		NO	
	35	00022	PSH00022	COAGULATED WATER SAMPLE PUMP DISCHARGE HIGH PRESSURE SWITCH	35-PI-04	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0002A	PI0002A	COAGULATED WATER SAMPLE PUMP DISCHARGE PRESSURE GAUGE	35-PI-04	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	10011	FIT10011	FLOC BASIN 1 INLET FLOW	35-PI-04	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	20011	FIT20011	FLOC BASIN 2 INLET FLOW	35-PI-04	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	00023	AIT00023	COAGULATED WATER STREAM CURRENT TRANSMITTER	35-PI-04	40 75 00	AC	CONDUCTIVITY ANALYZER							
	30	1201A	FI1201A	FLOC BASIN 1 STAGE 2 POLY FLOW 1	35-PI-06	40 71 00	FI	FLOW INDICATOR	N/A	1/2" NPT	TBD	N/A		NO	
	30	1202A	FI1202A	FLOC BASIN 1 STAGE 2 POLY FLOW 2	35-PI-06	40 71 00	FI	FLOW INDICATOR	N/A	1/2" NPT	TBD	N/A		NO	
	30	2201A	FI2201A	FLOC BASIN 2 STAGE 2 POLY FLOW 1	35-PI-09	40 71 00	FI	FLOW INDICATOR	N/A	1/2" NPT	TBD	N/A		NO	
	30	2202A	FI2202A	FLOC BASIN 2 STAGE 2 POLY FLOW 2	35-PI-09	40 71 00	FI	FLOW INDICATOR	N/A	1/2" NPT	TBD	N/A		NO	
	40	1001A	PI1001A	SED BASIN 1A UTILITY WATER PRESSURE	35-PI-11	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	40	1001A	FI1001A	FILTER INFLUENT TURB SAMPLE FLOW	35-PI-11	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	40	10004	AIT10004	FILTER INFLUENT TURBIDITY	35-PI-11	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	40	2001A	PI2001A	SED BASIN 2A UTILITY WATER PRESSURE	35-PI-13	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	40	2001A	FI2001A	FILTER INFLUENT TURB SAMPLE FLOW	35-PI-13	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	40	20004	AIT20004	FILTER INFLUENT TURBIDITY	35-PI-13	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	00016	LIT00016	FILTER INFLUENT CHANNEL LEVEL	35-PI-15	40 61 13.01	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	1015A	FI1015A	FILTER 1 PC SAMPLE FLOW	35-PI-16	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	1015B	FI1015B	FILTER 1 TURB SAMPLE FLOW	35-PI-16	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	10131	AIT10131	FILTER 1 BACKWASH TURBIDITY	35-PI-16	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	10141	AIT10141	FILTER 1 BACKWASH PARTICLE COUNT	35-PI-16	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	10111	LIT10111	FILTER 1 LEVEL	35-PI-16	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	10042	PIT10042	FILTER 1 PRESSURE TO WASTE	35-PI-16	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	10010	FIT10010	FILTER 1 COMBINDED FILTER WATER FLOW	35-PI-16	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	2015A	FI2015A	FILTER 2 TURB SAMPLE FLOW	35-PI-17	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	2015B	FI2015B	FILTER 2 PC SAMPLE FLOW	35-PI-17	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	20131	AIT20131	FILTER 2 BACKWASH TURBIDITY	35-PI-17	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	20141	AIT20141	FILTER 2 BACKWASH PARTICLE COUNT	35-PI-17	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	20111	LIT20111	FILTER 2 LEVEL	35-PI-17	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	20042	PIT20042	FILTER 2 PRESSURE TO WASTE	35-PI-17	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	20010	FIT20010	FILTER 2 COMBINDED FILTER WATER FLOW	35-PI-17	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	3015A	FI3015A	FILTER 3 TURB SAMPLE FLOW	35-PI-18	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	3015B	FI3015B	FILTER 3 PC SAMPLE FLOW	35-PI-18	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	30131	AIT30131	FILTER 3 BACKWASH TURBIDITY	35-PI-18	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	30141	AIT30141	FILTER 3 BACKWASH PARTICLE COUNT	35-PI-18	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	30111	LIT30111	FILTER 3 LEVEL	35-PI-18	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	30042	PIT30042	FILTER 3 PRESSURE TO WASTE	35-PI-18	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	30010	FIT30010	FILTER 3 COMBINDED FILTER WATER FLOW	35-PI-18	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	4015A	FI4015A	FILTER 4 PC SAMPLE FLOW	35-PI-19	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	4015B	FI4015B	FILTER 4 TURB SAMPLE FLOW	35-PI-19	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	40131	AIT40131	FILTER 4 BACKWASH TURBIDITY	35-PI-19	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	40141	AIT40141	FILTER 4 BACKWASH PARTICLE COUNT	35-PI-19	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	40111	LIT40111	FILTER 4 LEVEL	35-PI-19	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	

Item	Area	Loop Number	Tag	Description	P&ID	Specification	INSTRUSPEC Symbol	Instrument Type	Power Requirement	Size	Calibration Range	Set Point	Installation Detail	Equipment Vendor Provided	Application Notes
	35	40042	PIT40042	FILTER 4 PRESSURE TO WASTE	35-PI-19	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	40040	FIT40040	FILTER 4 COMBINDED FILTER WATER FLOW	35-PI-19	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	5015A	FI5015A	FILTER 5 TURB SAMPLE FLOW	35-PI-20	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	5015B	FI5015B	FILTER 5 PC SAMPLE FLOW	35-PI-20	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	50131	AIT50131	FILTER 5 BACKWASH TURBIDITY	35-PI-20	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	50141	AIT50141	FILTER 5 BACKWASH PARTICLE COUNT	35-PI-20	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	50111	LIT50111	FILTER 5 LEVEL	35-PI-20	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	50042	PIT50042	FILTER 5 PRESSURE TO WASTE	35-PI-20	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	50010	FIT50010	FILTER 5 COMBINDED FILTER WATER FLOW	35-PI-20	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	6015A	FI6015A	FILTER 6 TURB SAMPLE FLOW	35-PI-21	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	6015B	FI6015B	FILTER 6 PC SAMPLE FLOW	35-PI-21	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	60131	AIT60131	FILTER 6 BACKWASH TURBIDITY	35-PI-21	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	60141	AIT60141	FILTER 6 BACKWASH PARTICLE COUNT	35-PI-21	40 75 00	APC	PARTICLE COUNTER	120VAC	1/4" OD TUBING	2-175 MICROMETER	N/A		YES	
	35	60111	LIT60111	FILTER 6 LEVEL	35-PI-21	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	60042	PIT60042	FILTER 6 PRESSURE TO WASTE	35-PI-21	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	60010	FIT60010	FILTER 6 COMBINDED FILTER WATER FLOW	35-PI-21	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	00111	PSH00111	FINISHED WATER HIGH SAMPLE PUMP DISCHARGE PRESSURE	35-PI-22	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	00111A	PI00111A	FINISHED WATER SAMPLE PUMP PRESSURE	35-PI-22	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00112	PIT00112	FINISHED WATER SAMPLE PUMP PRESSURE	35-PI-22	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	35	00015A	FI00015A	FINISHED WATER TURB SAMPLE FLOW	35-PI-22	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	00151	AIT00151	FINISHED WATER TURBIDITY	35-PI-22	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	0001A	FI0001A	WASTE BACKWASH SAMPLE FLOW	35-PI-23	40 71 00	FI	FLOW INDICATOR	N/A	1/4" NPT	TBD	N/A		YES	
	35	00021	AIT00021	WASTE BACKWASH TURBIDITY	35-PI-23	40 75 00	ATI	OPTICAL INDICATING TURBIDIMETER	120VAC	1/4" OD TUBING	0-700 NTU	N/A		YES	
	35	00018	FIT00018	BACKWASH FLOW	35-PI-23	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	24"	TBD	N/A		NO	
	70	00011	TIT00011	AIR SCOUR BLOWER 1 INLET TEMP	35-PI-24	40 74 00	TMP	TEMPERATURE TRANSMITTER	N/A	1/2" MNPT	0-160 F	N/A		NO	
	70	00012	DPSH00012	AIR SCOUR BLOWER 1 INLET DP	35-PI-24	40 73 00	PDHS	DIFFERENTIAL PRESSURE SWITCH	N/A	1/8" FNPT	TBD	N/A		NO	
	70	0001A	TI0001A	AIR SCOUR BLOWER 1 OUTLET TEMP	35-PI-24	40 74 00	TI	TEMPERATURE INDICATOR	N/A	1/2" MNPT	0-160 F	N/A		NO	
	70	0001A	PI0001A	AIR SCOUR BLOWER 1 OUTLET PRESSURE	35-PI-24	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	0-15 psig	N/A		NO	
	70	0001A1	PI0001A1	AIR SCOUR BLOWER 1 SUCTION PRESSURE	35-PI-24	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	0-15 psig	N/A		NO	
	70	00021	TIT00021	AIR SCOUR BLOWER 2 INLET TEMP	35-PI-24	40 74 00	TMP	TEMPERATURE TRANSMITTER	N/A	1/2" MNPT	0-160 F	N/A		NO	
	70	00021	DPSH00022	AIR SCOUR BLOWER 2 INLET DP	35-PI-24	40 73 00	PDHS	DIFFERENTIAL PRESSURE SWITCH	N/A	1/8" FNPT	TBD	N/A		NO	
	70	0001B	TI0001B	AIR SCOUR BLOWER 2 OUTLET TEMP	35-PI-24	40 74 00	TI	TEMPERATURE INDICATOR	N/A	1/2" MNPT	0-160 F	N/A		NO	
	70	0001B	PI0001B	AIR SCOUR BLOWER 2 OUTLET PRESSURE	35-PI-24	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	0-15 psig	N/A		NO	
	70	0001B1	PI0001B1	AIR SCOUR BLOWER 2 SUCTION PRESSURE	35-PI-24	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	0-15 psig	N/A		NO	
	70	00014	TIT00014	AIR SCOUR TEMPERATURE	35-PI-24	40 74 00	TMP	TEMPERATURE TRANSMITTER	N/A	1/2" MNPT	0-160 F	N/A		NO	
	70	00015	PIT00115	AIR SCOUR PRESSURE	35-PI-24	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	0-50 psig	N/A		NO	
	84	00013	WIT00013	PEA WEIGHT	35-PI-28	40 73 00	????	LOAD CELL	LOOP	N/A	TBD	N/A		NO	
	84	10010	PSH10010	POLYMER BLENDING UNIT 1 HIGH DISCHARGE PRESSURE	35-PI-28	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		YES	
	84	0001A	PI0001A	POLYMER BLENDING UNIT 1 DISCHARGE PRESSURE	35-PI-28	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		YES	
	84	0001A	FI0001A	POLYMER BLENDING UNIT 1 WATER FLOW	35-PI-28	40 71 00	FI	FLOW INDICATOR	N/A	1" NPT	TBD	N/A		YES	
	84	20010	PSH20010	POLYMER BLENDING UNIT 2 HIGH DISCHARGE PRESSURE	35-PI-28	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		YES	
	84	0001B	PI0001B	POLYMER BLENDING UNIT 2 DISCHARGE PRESSURE	35-PI-28	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		YES	
	84	0001B	FI0001B	POLYMER BLENDING UNIT 2 WATER FLOW	35-PI-28	40 71 00	FI	FLOW INDICATOR	N/A	1" NPT	TBD	N/A		YES	
	84	00014	FSL00014	EYEWASH STATION ACTIVATED FLOW SWITCH	35-PI-28	40 71 00	FPS	POSITION FLOW SWITCH	N/A						
	35	00021	PSH00021	PEA FEED PUMP 1 HIGH DISCHARGE PRESSURE	35-PI-29	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0001D	PI0001D	PEA FEED PUMP 1 DISCHARGE PRESSURE	35-PI-29	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00031	PSH00031	PEA FEED PUMP 2 HIGH DISCHARGE PRESSURE	35-PI-29	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0001E	PI0001E	PEA FEED PUMP 2 DISCHARGE PRESSURE	35-PI-29	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00021	LIT00021	PEA BATCH TANK LEVEL	35-PI-29	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	0001C	FI0001C	UTILITY WATER FLOW	35-PI-29	40 71 00	FI	FLOW INDICATOR	N/A	TBD	TBD	N/A		NO	
	35	00015	FIT00015	PEA FEED FLOW	35-PI-29	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	00043	PSH00043	PEA FEED PUMP 3 HIGH DISCHARGE PRESSURE	35-PI-30	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0001F	PI0001F	PEA FEED PUMP 3 DISCHARGE PRESSURE	35-PI-30	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00042	FIT00042	PEA FEED PUMP 3 DISCHARGE FLOW	35-PI-30	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	0001D	FI0001D	PEA FEED PUMP 3 UTILITY WATER FLOW	35-PI-30	40 71 00	FI	FLOW INDICATOR	N/A	TBD	TBD	N/A		NO	
	35	00051	PSH00051	PEA FEED PUMP 4 HIGH DISCHARGE PRESSURE	35-PI-30	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0001G	PI0001G	PEA FEED PUMP 4 DISCHARGE PRESSURE	35-PI-30	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00052	FIT00052	PEA FEED PUMP 4 DISCHARGE FLOW	35-PI-30	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	0001E	FI0001E	PEA FEED PUMP 4 UTILITY WATER FLOW	35-PI-30	40 71 00	FI	FLOW INDICATOR	N/A	TBD	TBD	N/A		NO	
	35	00061	PSH00061	PEA FEED PUMP 5 HIGH DISCHARGE PRESSURE	35-PI-30	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		NO	
	35	0001H	PI0001H	PEA FEED PUMP 5 DISCHARGE PRESSURE	35-PI-30	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	35	00062	FIT00062	PEA FEED PUMP 5 DISCHARGE FLOW	35-PI-30	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	TBD	TBD	N/A		NO	
	35	0001F	FI0001F	PEA FEED PUMP 5 UTILITY WATER FLOW	35-PI-30	40 71 00	FI	FLOW INDICATOR	N/A	TBD	TBD	N/A		NO	
	35	00011	LIT00011	SOLIDS COLLECTION BOX LEVEL	35-PI-31	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	35	00012	FIT00012	SOLIDS COLLECTION BOX OUTLET FLOW	35-PI-31	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	10"	TBD	N/A		NO	
	35	00011	LSH00011	TREATMENT BLDG. RECYCLE LEVEL HIGH	35-PI-32	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	00011	LSM00011	TREATMENT BLDG. RECYCLE LEVEL PUMP ON	35-PI-32	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	00011	LSL00011	TREATMENT BLDG. RECYCLE LEVEL LOW/PUMP OFF	35-PI-32	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	00101	LSH00101	TREATMENT BLDG. DRAINAGE LEVEL HIGH	35-PI-33	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	00101	LSM00101	TREATMENT BLDG. DRAINAGE LEVEL PUMP ON	35-PI-33	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	00101	LSL00101	TREATMENT BLDG. DRAINAGE LEVEL LOW/PUMP OFF	35-PI-33	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	35	10055	FIT10055	COMBINED FTW HEADER FLOW	35-PI-34	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	14"	TBD	N/A		NO	
	60	00012	LIT00012	WASTE BACKWASH WATER CLARIFIER LEVEL	60-PI-01	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	

Item	Area	Loop Number	Tag	Description	P&ID	Specification	INSTRUSPEC Symbol	Instrument Type	Power Requirement	Size	Calibration Range	Set Point	Installation Detail	Equipment Vendor Provided	Application Notes
	60	00014	LSH00014	RECYCLE PUMP STATION LEVEL HIGH	60-PI-02	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	60	00014	LSM00014	RECYCLE PUMP STATION LEVEL MID	60-PI-02	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	60	00014	LSL00014	RECYCLE PUMP STATION LEVEL LOW	60-PI-02	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	70	10010	LIT10010	CLEARWELL BASIN LEVEL	70-PI-01	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	70	20010	LIT20010	CLEARWELL BASIN LEVEL	70-PI-01	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	70	00060	LSLL00060	CLEARWELL LOW LEVEL SWITCH	70-PI-01	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	70	00010	FIT00010	MORRIS PIPELINE FLOW	70-PI-01	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	14"	TBD	N/A		NO	
	70	00020	FIT00020	CITY PIPELINE FLOW	70-PI-01	40 71 00	FM	MAGNETIC FLOW METERING SYSTEM	120VAC	14"	TBD	N/A		NO	
	70	00011	PSH00011	TREATED WATER SAMPLE PUMP HIGH DISCHARGE PRESSURE	70-PI-02	40 73 00	PS	PRESSURE SWITCH	N/A	1/2" FNPT	N/A	TBD		YES	
	70	00012	PI00012	TREATED WATER SAMPLE PUMP DISCHARGE PRESSURE	70-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00012	PIT00012	TREATED WATER SAMPLE PUMP DISCHARGE PRESSURE	70-PI-02	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	70	00016	FI00016	TREATED WATER PUMP SAMPLE FLOW	70-PI-02	40 71 00	FI	FLOW INDICATOR	N/A	1 1/2" NPT	TBD	N/A		YES	
	70	00013	AIT00013	TREATED WATER pH	70-PI-02	40 75 00	AH	pH ANALYZER	120VAC	TBD	0-14	TBD		YES	
	70	00014	AIT00014	TREATED WATER CHLORINE	70-PI-02	40 75 00	CLR	CHLORINE RESIDUAL ANALYZER	120VAC	3/4" NPT	TBD	TBD		YES	
	70	00015	AIT00015	TREATED WATER FLOURIDE	70-PI-02	40 75 00	????	FLOURIDE ANALYZER?	120VAC	3/4" NPT	TBD	TBD		YES	
	70	00072	PI00072	CARRIER WATER PRESSURE	70-PI-02	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00072	PIT00072	CARRIER WATER PRESSURE	70-PI-02	40 73 00	PGT	GAUGE PRESSURE TRANSMITTER	LOOP	1/2" FNPT	TBD	N/A		NO	
	70	00014	LIT00014	CLEARWELL PLANT WATER PUMP STATION LEVEL	70-PI-03	40 72 00	LUT	ULTRASONIC LEVEL TRANSMITTER	120VAC	1" MNPT	1-50 FT	N/A		NO	
	70	00015	LSLL00015	CLEARWELL PLANT WATER PUMP STATION LEVEL LOW	70-PI-03	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	70	0001A	PI0001A	CLEARWELL PLANT WATER PUMP 1 DISCHARGE PRESSURE	70-PI-03	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00012	FSL00012	CLEARWELL PLANT WATER PUMP 1 DISCHARGE LOW FLOW	70-PI-03	40 71 00	FTS	FLOW SWITCH	120VAC	1" NPT	TBD	N/A		NO	
	70	0001B	PI0001B	CLEARWELL PLANT WATER PUMP 2 DISCHARGE PRESSURE	70-PI-03	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00022	FSL00022	CLEARWELL PLANT WATER PUMP 2 DISCHARGE LOW FLOW	70-PI-03	40 71 00	FTS	FLOW SWITCH	120VAC	1" NPT	TBD	N/A		NO	
	70	0001A	PI0001A	CLEARWELL BACKWASH PUMP 1 DISCHARGE PRESSURE	70-PI-04	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00012	FSL00012	CLEARWELL BACKWASH PUMP 1 DISCHARGE LOW FLOW	70-PI-04	40 71 00	FTS	FLOW SWITCH	120VAC	1" NPT	TBD	N/A		NO	
	70	0001B	PI0001B	CLEARWELL BACKWASH PUMP 2 DISCHARGE PRESSURE	70-PI-04	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00022	FSL00022	CLEARWELL BACKWASH PUMP 2 DISCHARGE LOW FLOW	70-PI-04	40 71 00	FTS	FLOW SWITCH	120VAC	1" NPT	TBD	N/A		NO	
	70	0001C	PI0001B	CLEARWELL BACKWASH PUMP 3 DISCHARGE PRESSURE	70-PI-04	40 73 00	PG	PRESSURE GAUGE	N/A	1/2" MNPT	TBD	N/A		NO	
	70	00032	FSL00032	CLEARWELL BACKWASH PUMP 3 DISCHARGE LOW FLOW	70-PI-04	40 71 00	FTS	FLOW SWITCH	120VAC	1" NPT	TBD	N/A		NO	
	70	00016	LIT00016	BACKWASH HEAD BOX LEVEL	70-PI-05	40 72 00	LRFM	RADAR LEVEL TRANSMITTER	120VAC	4" 150# FLANGED	0-66 FT	N/A		NO	
	70	00017	LSH00017	CLEARWELL UNDERDRAIN LEVEL HIGH	70-PI-06	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	70	00017	LSM00017	CLEARWELL UNDERDRAIN LEVEL PUMP ON	70-PI-06	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	70	00017	LSL00017	CLEARWELL UNDERDRAIN LEVEL LOW/PUMP OFF	70-PI-06	40 72 00	LFS	FLOAT SWITCH	N/A	N/A	N/A	TBD		NO	
	87	00012	FSL00012	INSIDE FLOURIDE STORAGE EYEWASH STATION ON	87-PI-01	40 61 13.01	FTS	FLOW SWITCH	N/A	1" NPT	TBD	N/A		YES	
	87	00013	FSL00013	OUTSIDE FLOURIDE STROAGE EYEWASH STATION ON	87-PI-01	40 61 13.01	FTS	FLOW SWITCH	N/A	1" NPT	TBD	N/A		YES	
	87	00061	FSL00061	FLOURIDE CARRIER WATER LOW FLOW SWITCH	87-PI-01	40 61 13.01	FTS	FLOW SWITCH	N/A	N/A	N/A	TBD		NO	

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SECTION 40 61 21

PROCESS CONTROL SYSTEM TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies testing requirements applicable to Sections 40 60 00 through 40 79 99 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a PICS Testing Manager meeting the Qualifications section of this specification. Section includes:

1. Testing documentation.
2. Testing organization and sequencing.
3. Factory Acceptance Testing (FAT)
4. Performance testing.
5. Loop testing.
6. Functional testing.
7. Operational testing.

B. Related sections:

1. Section 40 61 13 – Process Control System General Provisions
2. Section 40 61 93 – Process Control System Input/Output List
3. Section 40 61 96 – Process Control Descriptions

1.02 REFERENCES

A. Definitions:

1. The term “instrumentation” covers field and panel instruments, analyzers, primary sensing elements, transmitters, power supplies, and monitoring devices.

B. Reference Standards:

1. This section contains references to the following documents with additional references listed in Section 40 61 13.
    a. References are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the referenced documents, the requirements of this section prevail.
    b. Version: Latest documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no bids) unless noted otherwise.
    c. If referenced documents have been discontinued by the issuing organization, use the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

d. Where document dates are given in the following listing, reference to those documents means the specific document version associated with that date, whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ISA RP7.1	Pneumatic Control Circuit Pressure Test
ISA S51.1	Process Instrumentation Terminology

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate testing with Section 01 45 20.
   2. Provide notice to the Construction Manager prior to conducting a test.
   3. Provide a detailed step-by-step test procedure, between 60 and 70 days before the commencement of testing activity, complete with forms for the recording of test results, testing equipment used, and a place for identification of the individuals performing and witnessing the test.
   4. Provide detail assistance to the Contractor in generating Section 01 45 20 Form A, customized for this project. Submit detailed form prior to testing per the requirements of Section 01 45 20.
   5. Equipment and System Performance and Operational Testing: Section 01 45 20 specifies testing of the mechanical, electrical, instrumentation, and HVAC systems. Coordinate, manage, and supervise the work with the quality assurance program including:
      a. Testing plan with the sequence for the test work.
      b. Calibration program for instruments and analyzers.
      c. Documentation program that records tests results.
      d. Performance testing program systems.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Action Submittals:
   1. Quality Assurance submittal:
      a. PICS Testing Manager Qualifications.
      b. Testing Technician Qualifications
      c. Network Testing Firm Qualification
      d. Proposed process area and process system organization
   2. Testing submittal:
      a. Submit detailed testing plan and proposed testing documentation after review of the Quality Assurance submittal showing conformance with Part 2 of this specification. Obtain approved submittal prior to testing.
         1) Control descriptions.
         2) Input/Output (I/O) interface.
         3) Testing status spreadsheets.

4) Test procedures.
5) Proposed test forms per this section, detailed for each test for this project.

3. FAT:
   a. FAT schedule and location.
   b. FAT procedures and test forms

C. Closeout Submittals
1. Final Test Report assembled in a three-ring binder, including a CD-R, and submitted at the completion of the inspection and testing activities for a process area.
   a. Label the binder cover and spine to identify the project name and process area. Include in the test report the applicable test procedures for the process area and the completed inspection and test report forms associated with the equipment and systems of that area.
   b. Organize test results by equipment item or system with individual, labeled tab dividers to identify each. The responsible testing entity is to acknowledge system deficiencies and noncompliant test results identified in the final test report as corrected.
   c. Documentation of network data communication nodes for network-type instruments, devices, and variable-frequency drives.
   d. Test equipment and test equipment calibration date.
   e. Certified factory calibration reports for flow and temperature transmitters.
   f. Performance test results.
   g. Loop test results.
   h. Functional test results.
   i. Operational test results.

1.05 QUALITY ASSURANCE

A. Addressed in Section 40 61 13.

PART 2 PRODUCTS

2.01 TESTING DOCUMENTATION

A. Documentation Records:
1. Develop a record-keeping system to document progress and completion for each task in each process area or system. Coordinate overall organization of areas and systems with overall testing required by Section 01 45 20, Equipment and System Performance and Operational Testing.
2. Always keep documentation current and available for inspection on site in a location designated by the Construction Manager:
   a. PICS Testing Manager's qualifications, project startup, and testing history.
   b. List of names of Contractor's and SI's personnel associated with final construction and testing, and normal and emergency contact telephone numbers.
   c. Testing Status spreadsheet with breakdown for each process area and process system, with percentage complete on each testing sequence task.

d. Testing status specific to pre-loop test and loop testing status spreadsheet to include the I/O list organized by area and system and loop number. Percent complete of the PICS system will be based on percentage of I/O points tested.
e. Test Report Volumes.

B. Test Report Volumes:
1. Develop and maintain testing documentation for each process area or system in separate volumes. Always keep each volume current and available for inspection on site in a location designated by the Construction Manager. Include the following as a minimum:
a. Three-ring binder with front cover and spine labeled: “Testing Documentation for (applicable) Process Area / Process System” including project labeling.
b. Table of Contents with same labeling as the volume cover with tabs for each section:
c. Section 1: Control Description
d. Section 2: I/O Interface
e. Section 3: Instrument Index
f. Section 4: Test Procedures and Forms
g. Section 5: Certified Factory Calibration Reports
h. Section 6: Test Report

C. Control Description:
1. Provide a control description outlining operation for each process area’s system. The Control Description Specification Section 40 61 96 may be used as a basis.

D. I/O Interface:
1. Provide I/O spreadsheets for each process area’s system. Spreadsheets are to include the following for each I/O point:
a. Information shown in Section 40 61 93
b. Signal number/tag
c. Annotation description that may be logically abbreviated and that is subject to approval
d. Complete physical I/O channel designation and addressing or communication I/O register designation
e. True/false status designations for digital I/O
f. Process range; engineering units and multipliers; and raw signal range count for analog I/O
g. Signals: Fixed point and scaled at the controller with minimum four significant implied digits of scaling; e.g., 0 to 1,400 at controller for a pH range of 0 to 14 at operator interface
h. Provide operator interface scaling to display decimal digits required
i. Indicate pass/fail for each point for both pre-loop test and loop tests
j. Indicate date of tests and comment for failed points

E. Instrument List:
   1. Provide a detailed Instrument List. Indicate actual calibration ranges, set points, and deadbands.

F. Field Test Procedure Documentation:
   1. Organize and assemble test procedures for each analog and discrete loop in the process control system in separate volumes for each process area or test group. Organize by I/O point. Submit final test records in electronic form by scanning and converting the records and files to .pdf format, to preserve actual signatures and signoffs.
   2. Include a detailed, step-by-step description of the required test procedure, panel and terminal block numbers for points of measurement, input test values, expected resultant values, test equipment required, process setup requirements, and safety precautions.
   3. Include test report forms for each loop, including forms for wiring, piping, and individual component tests, with the test procedure documentation. Record the actual test results on these forms and assemble them into final test reports.
   4. Preprint and populate information in the test report forms to the extent possible prior to commencing testing.
   5. Include on the test report forms:
      a. Project name
      b. Process area associated with the equipment under test
      c. Instrument loop description
      d. Instrument loop identification number
      e. Instrument nameplate data
      f. Instrument setup and configuration parameters
      g. Time and date of test
      h. Inspection checklist and results
      i. Reference to applicable test procedure
      j. Expected and actual test results for each test point in the loop including programmable controller data table or register values
      k. Test equipment used
      l. Space for remarks regarding test procedure or results, observations, etc.
      m. Name, date, and signature of testing personnel
      n. Test witness's name and signature

2.02 SOURCE QUALITY CONTROL

A. Factory Acceptance Test (FAT):
   1. Provide a FAT with the test and subsequent retests witnessed by the Construction Manager and Owner or Owner's Representative. This modified FAT shall address only the new equipment, hardware, and software to be added to the facility as part of this project.
   2. Load software and configuration for control system panels, network components, operator interfaces, servers, and the programming and graphic configuration application at the control system equipment supplier's factory prior to the FAT.

3. Inspect equipment, panel instruments, panels, or cabinets with factory testing performed
4. Provide written notice to the Construction Manager 30 working days before the commencement of the FAT activity and include:
    a. Schedule for the FAT
    b. Location of the FAT
    c. Testing equipment used
    d. Detailed test procedure with forms for the recording of test results
    e. Sign-off spaces for the individuals performing and witnessing the tests
5. Network and interwire equipment and panels as applicable. Operate and check out equipment prior to the FAT. Submit certification indicating that the panels are ready for the FAT. Include the following:
    a. Visual inspection of equipment, instruments, control panels, and graphic displays
    b. Validation of each input loop and output loop by simulated signals for analog inputs and by shorting discrete inputs
    c. Validation includes:
        1) Monitoring state changes on operator interface screens based on the inputs state change
        2) Observation of online controller programming application software with the associated outputs state change
        3) Outputs triggered by operator interface software devices (pushbuttons, sliders, manually entered values, etc.)
        4) Calibration and operation of instruments on or in the control panels
    d. Repair of loops that do not pass validation
    e. Retest of the FAT at no additional cost.

PART 3 EXECUTION

3.01 GENERAL

A. General Requirements:
1. Provide the labor, tools, material, power, and services necessary to provide the process instrumentation and control system inspection and testing specified herein.
2. Inspect materials, equipment, and construction included under this specification in accordance with this section and subsequent sections of this division. Perform testing in accordance with this and subsequent sections of this division.
3. Have a certified instrument technician qualified to calibrate the instrumentation calibrate and set up field instruments and analyzers.

B. Test Equipment and Materials:
1. Provide test equipment to conduct the specified tests that simulate inputs and read outputs with a rated accuracy at the point of measurement at least three times greater than the component under test.
2. Provide a calibration sticker on test instruments showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required. Include certified calibration reports traceable to the National Institute of Standards and Technology with the final test report.

3. Provide a documenting calibration system to conduct process instrumentation calibration activities that consist of a documenting process calibrator and an instrumentation data management software system that captures the calibration results and electronically document instrument data, date of calibration, calibration procedures, and as-found and as-left instrument calibration data.
4. Provide an instrument calibration system such as Fluke 743B with Fluke DPC/Track Instrumentation Management software, or similar system. Submit calibration files with the final test report in hard-copy and electronic formats that does not require specialized equipment or software to read and print the files.
5. Provide buffer solutions and reference fluids for tests of analytical equipment.
6. Provide a communications and software package to record final configuration parameters and settings for variable-frequency drives with the parameters acquired by connection to the network that record the configuration settings without manual data entry or transcription of values.
7. Vendor software tools may document the systems where a licensed copy of the identical software including connectors, cables, keys, interface cards, and devices required for operation is submitted with the final documentation files.

C. Performance Deviation Tolerances:
1. Tolerances are specified in individual sections. Where tolerances are not specified, refer to the manufacturer's published performance specifications.
2. Calculate overall accuracy requirements for loops consisting of two or more components, by the root-summation-square (RSS) of the component accuracy specifications. Calculate and record tolerances for each required calibration point on the associated test report form.

D. Witnessing:
1. The Engineer reserves the right to observe factory and field instrumentation testing and calibration procedures. Notify the Construction Manager prior to testing, as specified herein.

3.02 TESTING SEQUENCE

A. Perform tests for each area or system in the following sequence:
1. Performance testing
2. Loop testing
3. Functional testing
4. Operational testing

B. Group equipment and I/O based on the relationship of the equipment to operate safely as specified, including full automatic and manual control and monitoring through the control system. Equipment and I/O in a given area or system shall pass testing prior to proceeding to the next set of tests in the sequence above.

3.03 PERFORMANCE TESTING

A. Perform tests in the order below.

B. Wiring Tests:
   1. Verify that electrical power and signal cable ring-out and resistance testing has been performed as specified in Sections 26 05 00 and 26 08 00. Conduct wiring tests after cables have been properly terminated, tagged, and inspected.

C. Pre-Loop Testing:
   1. Test every I/O point from the field device to the termination on the I/O card in the panel.
   2. Perform tests with loop wiring complete and terminated for each point being tested between initial field device and I/O termination point.
   3. For each discrete I/O point, verify and document contact status value for both the opened and closed positions of the contact.
   4. For analog points, verify analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

3.04 LOOP TESTING

A. Provide a request to perform loop testing at least 2 weeks prior to the requested loop test date. Include the following with the request:
   1. Area/system for which request is being made.
   2. Written certification that performance testing has been completed, documented, and passed for the area/system for which loop testing is being requested.
   3. Submittal numbers that define the tests and data points for the I/O to be tested. Provide updates to the I/O list or instrument calibration as an outcome of the performance testing.

B. Commence loop testing after the performance testing has been completed and documented to the satisfaction of the Owner or Owner's Representative.

C. Test each instrument loop as an integrated system. Check operation from field instruments to transmitter to receiving components to the vendor panel or the Plant Control System Operator Interface Station. Inject test signals at the process impulse line connection where the measuring technique permits, and otherwise at the most primary signal access point.

D. For each discrete I/O point, verify and document field contact status value for both the opened and closed position of the contact.

E. For analog points, verify that analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

F. Where loops are interfaced to a controller, verify the controller I/O assignment and operation of the input/output system and processor. Inspect the data table or register in the PLC memory to verify proper operation.

G. If the output control or monitoring device fails to indicate properly, make corrections to the loop circuitry or device. Repeat the test until devices and instruments operate as required.

H. Correct loop circuitry and repeat the test until the instruments operate properly.

3.05 FUNCTIONAL TESTING

A. Process Control Strategy/Functional Testing:
   1. Commence control strategy testing after loop testing has been completed and documented to the satisfaction of the Owner or Owner's Representative.
   2. Coordinate control strategy testing with the PLC/HMI programmer. Testing to consist of installing and debugging the PLC equipment, verifying the interface points between the controller I/O cards and field devices and equipment, and exercising the control strategies. Control strategy testing to be performed on one PLC at a time.
   3. Provide qualified personnel to immediately correct deficiencies in the work that may be encountered during control strategy testing. Failure of the Contractor to provide such personnel in a timely manner may prolong the time allotted to complete control strategy testing.

B. Control System Closed-Loop Testing:
   1. Coordinate and commence closed-loop commissioning after the control strategy testing has been successfully completed and documented to the satisfaction of the Owner or Owner's Representative.
   2. Where a loop is controlled under the direction of a PLC, the Programmer, along with the SI, will perform the necessary adjustment of loop tuning parameters and set points, record the loop response, adjusting final elements, and ensuring total integrated loop performance as specified.

C. Functional Checkout:
   1. Conduct to verify the operation of discrete and hardwired control devices, refer to Section 01 45 20. Exercise the operable devices and energize the control circuit. Operate control element, alarm device, and interlocks to verify that the specified action occurs.

3.06 OPERATIONAL TESTING

A. Coordinate with the PLC/HMI programmer. Perform the Operational Tests after component and subsystem tests have been completed. Perform the test of the completed system in full operation and demonstrate that functional requirements of this specification have been met. Demonstrate the following:
   1. Each component of the system operates correctly with other components of the system.
   2. Analog control loops operate in a stable manner.
   3. Hard-wired and software equipment interlocks perform correctly.
   4. Process control sequences perform correctly.
   5. Application program performs monitoring and control functions correctly.
   6. Operator interface graphics represent the monitoring and control functions correctly.

END OF SECTION

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SECTION 40 61 93

PROCESS CONTROL SYSTEM INPUT/OUTPUT LIST

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Input/output (I/O) list showing the following types of points that interface with the control system:
      a. Points that are hardwired into the control system.
      b. Points that are interfaced to the control system over a communications link.
   2. The I/O list does not include internal software points generated by the control system and used solely within the control system.

B. Related sections:
   1. Refer to Section 40 61 13.01 – Process Control Systems General Provisions for Small Projects.
   2. Refer to Section 40 61 21 – Process Control System Testing.

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Submittal grouping:
   1. Submit process and instrument control system instrumentation, hardware, and software together as an integrated system in staged submittal groupings as defined in Section 40 61 13.01. What should be in each submittal grouping is clarified in the following paragraphs.

C. Action Submittal:
   1. Panels and Consoles submittal group. Submit I/O information applicable to the equipment and panels within the submittal group.

D. Informational Submittal: Provide a copy of the electronic version of the complete list to the Owner, at least monthly, when requested.

PART 2 NOT USED

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Refer to Section 40 61 21.

B. Maintain a copy of the complete Input/Output List with modifications during construction in Excel format.

3.02 ATTACHMENTS

A. Attachment A: Input/Output (I/O) List

1. Description of headings in Input/Output (I/O) List.

Field or Heading	Example	Comment or Description
Tag No. Function Abbreviation	PDI	See tagging on instrument legend sheets.
Tag No. Area Code	01	See tagging on instrument legend sheets.
Tag No. Loop Identifier	23	See tagging on instrument legend sheets.
Tag No. Suffix 1	A	See tagging on instrument legend sheets.
Tag No. Suffix 2	1	See tagging on instrument legend sheets.
Description		Match contract drawings.
Panel	LCP-14	Number or tag to match contract documents
PLC or DCU	PLC-14	Number or tag to match contract documents
RIO		Number or tag to match contract documents
Rack or IP Address	01	Match contract drawing, or if not shown, match to submittal information.
Slot or Segment	03	Match contract drawing, or if not shown, match to submittal information.
Point or Node	07	Match contract drawing, or if not shown, match to submittal information.
Comm Channel or Module		Match contract drawing, or if not shown, match to submittal information.
I/O Type	AI	AI, DI, DO, AO
Module or Signal Type	4-20 mA	-20 mA, Ethernet, DeviceNet, Discrete Contact, etc.
Min Calibration or Function Low	0	0, Open, Normal
Max Calibration or Function High	55	55, Not Open, Fail
Units	PSIG	mgd, kW, psi, etc.
Application Notes or Comments		Optional, as required for clarification.
P&ID Number		Contract P&ID drawing
Wiring Diagram		Contract Wiring diagram.
Internal Address		Internal address associated with I/O point.
Alarm	No	Yes or No
Alarm Priority		1, A, 7A, etc.
Testing Group System	Secondary.	As required for testing
Testing Group SubSystem	RSS Pumping	As required for testing
Testing Group Equipment	RSS Pump No. 1	As required for testing

END OF SECTION

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	01	00007	1	LAH00007-1	INFILTRATION GALARY HIGH LIEVEL ALARM	01-PI-01		35-PLC-9000	DI	120VAC					
	01	00007	1	LAM00007-1	INFILTRATION GALARY MID LIEVEL ALARM	01-PI-01		35-PLC-9000	DI	120VAC					
	01	00007	1	LAL00007-1	INFILTRATION GALARY LOW LIEVEL ALARM	01-PI-01		35-PLC-9000	DI	120VAC					
	01	00010	3	HS00010-3	INFILTRATION GALLERY PUMP 1 IN AUTO	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00010	2	YL00010-2	INFILTRATION GALLERY PUMP 1 RUNNING	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00010	2	YA00010-2	INFILTRATION GALLERY PUMP 1 FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00010	1	YC00010-1	INFILTRATION GALLERY PUMP 1 START	35-PI-01		35-PLC-9000	DO	120VAC					
	01	00010	1	MAH00010-1	INFILTRATION GALLERY PUMP 1 MOISTURE	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00010	1	TAH00010-1	INFILTRATION GALLERY PUMP 1 HIGH MOTOR WINDING TEMP	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00020	3	HS00020-3	INFILTRATION GALLERY PUMP 2 IN AUTO	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00020	2	YL00020-2	INFILTRATION GALLERY PUMP 2 RUNNING	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00020	2	YA00020-2	INFILTRATION GALLERY PUMP 2 FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00020	1	YC00020-1	INFILTRATION GALLERY PUMP 2 START	35-PI-01		35-PLC-9000	DO	120VAC					
	01	00020	1	MAH00020-1	INFILTRATION GALLERY PUMP 2 MOISTURE	35-PI-01		35-PLC-9000	DI	120VAC					
	01	00020	1	TAH00020-1	INFILTRATION GALLERY PUMP 2 HIGH MOTOR WINDING TEMP	35-PI-01		35-PLC-9000	DI	120VAC					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	89	00010	3	HS00010-3	SODIUM HYPOCHLORITE TRANSFER PUMP IN AUTO	03-PI-01		ACC2101	DI	120VAC					
	89	00010	1	YL00010-1	SODIUM HYPOCHLORITE TRANSFER PUMP RUNNING	03-PI-01		ACC2101	DI	120VAC					
	89	00010	1	YA00010-1	SODIUM HYPOCHLORITE TRANSFER PUMP FAULT	03-PI-01		ACC2101	DI	120VAC					
	89	00010	1	YC00010-1	SODIUM HYPOCHLORITE TRANSFER PUMP START	03-PI-01		ACC2101	DO	120VAC					
	89	00011	1	PI00011-1	SODIUM HYPOCHLORITE TRANSFER PUMP PRESSURE	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00012	3	HS00012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE IN REMOTE	03-PI-01		ACC2101	DI	120VAC					
	89	00012	1	ZIO00012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE OPENED	03-PI-01		ACC2101	DI	120VAC					
	89	00012	1	ZIC00012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE CLOSED	03-PI-01		ACC2101	DI	120VAC					
	89	00012	1	YA00012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE FAULT	03-PI-01		ACC2101	DI	120VAC					
	89	00012	1	ZC000012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE OPEN COMMAND	03-PI-01		ACC2101	DO	120VAC					
	89	00012	1	ZCC00012-1	SODIUM HYPOCHLORITE DAY TANK 1 VALVE CLOSE COMMAND	03-PI-01		ACC2101	DO	120VAC					
	89	00010	1	LI00010-1	SODIUM HYPOCHLORITE DAY TANK LEVEL	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00010	1	LALL00010-1	SODIUM HYPOCHLORITE DAY TANK LEVEL LOW LOW ALARM	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00010	1	LAHH00010-1	SODIUM HYPOCHLORITE DAY TANK LEVEL HIGH HIGH ALARM	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00020	3	HS00020-3	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 IN AUTO	03-PI-01		ACC2101	DI	120VAC					
	89	00020	1	YL00020-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 RUNNING	03-PI-01		ACC2101	DI	120VAC					
	89	00020	1	YA00020-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 FAULT	03-PI-01		ACC2101	DI	120VAC					
	89	00020	1	YC00020-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 START	03-PI-01		ACC2101	DO	120VAC					
	89	00021	1	PI00021-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 1 PRESSURE	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00030	3	HS00030-3	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 IN AUTO	03-PI-01		ACC2101	DI	120VAC					
	89	00030	1	YL00030-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 RUNNING	03-PI-01		ACC2101	DI	120VAC					
	89	00030	1	YA00030-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 FAULT	03-PI-01		ACC2101	DI	120VAC					
	89	00030	1	YC00030-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 START	03-PI-01		ACC2101	DO	120VAC					
	89	00031	1	PI00031-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 2 PRESSURE	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00013	1	PI00013-1	SODIUM HYPOCHLORITE RECIRCULATION LOOP 1 PRESSURE	03-PI-01		ACC2101	AI	4 - 20 mA					
	89	00022	3	HS00022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE IN REMOTE	03-PI-02		ACC2101	DI	120VAC					
	89	00022	1	ZIO00022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE OPENED	03-PI-02		ACC2101	DI	120VAC					
	89	00022	1	ZIC00022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE CLOSED	03-PI-02		ACC2101	DI	120VAC					
	89	00022	1	YA00022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE FAULT	03-PI-02		ACC2101	DI	120VAC					
	89	00022	1	ZC000022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE OPEN COMMAND	03-PI-02		ACC2101	DO	120VAC					
	89	00022	1	ZCC00022-1	SODIUM HYPOCHLORITE DAY TANK 2 VALVE CLOSE COMMAND	03-PI-02		ACC2101	DO	120VAC					
	89	00020	1	LI00020-1	SODIUM HYPOCHLORITE DAY TANK 2 LEVEL	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00020	1	LALL00020-1	SODIUM HYPOCHLORITE DAY TANK 2 LEVEL LOW LOW ALARM	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00020	1	LAHH00020-1	SODIUM HYPOCHLORITE DAY TANK 2 LEVEL HIGH HIGH ALARM	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00040	3	HS00040-3	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 IN AUTO	03-PI-02		ACC2101	DI	120VAC					
	89	00040	1	YL00040-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 RUNNING	03-PI-02		ACC2101	DI	120VAC					
	89	00040	1	YA00040-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 FAULT	03-PI-02		ACC2101	DI	120VAC					
	89	00040	1	YC00040-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 START	03-PI-02		ACC2101	DO	120VAC					
	89	00041	1	PI00041-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 3 PRESSURE	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00050	3	HS00050-3	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 IN AUTO	03-PI-02		ACC2101	DI	120VAC					
	89	00050	1	YL00050-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 RUNNING	03-PI-02		ACC2101	DI	120VAC					
	89	00050	1	YA00050-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 FAULT	03-PI-02		ACC2101	DI	120VAC					
	89	00050	1	YC00050-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 START	03-PI-02		ACC2101	DO	120VAC					
	89	00051	1	PI00051-1	SODIUM HYPOCHLORITE RECIRCULATION PUMP 4 PRESSURE	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00023	1	PI00023-1	SODIUM HYPOCHLORITE RECIRCULATION LOOP 2 PRESSURE	03-PI-02		ACC2101	AI	4 - 20 mA					
	89	00080	1	HS00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 IN AUTO	03-PI-03		ACC2101	DI	120VAC					
	89	00080	1	YL00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 RUNNING	03-PI-03		ACC2101	DI	120VAC					
	89	00080	1	YA00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 FAULT	03-PI-03		ACC2101	DI	120VAC					
	89	00080	1	YC00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 START	03-PI-03		ACC2101	DO	120VAC					
	89	00080	1	SC00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 SPEED SETPT	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00080	1	SI00080-1	SODIUM HYPOCHLORITE FEED PUMP 3 SPEED	03-PI-03		ACC2101	AO	4 - 20 mA					
	89	00081	1	PI00081-1	SODIUM HYPOCHLORITE FEED PUMP 3 OUTLET PRESSURE	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00060	1	HS00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 IN AUTO	03-PI-03		ACC2101	DI	120VAC					
	89	00060	1	YL00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 RUNNING	03-PI-03		ACC2101	DI	120VAC					
	89	00060	1	YA00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 FAULT	03-PI-03		ACC2101	DI	120VAC					
	89	00060	1	YC00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 START	03-PI-03		ACC2101	DO	120VAC					
	89	00060	1	SC00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 SPEED SETPT	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00060	1	SI00060-1	SODIUM HYPOCHLORITE FEED PUMP 1 SPEED	03-PI-03		ACC2101	AO	4 - 20 mA					
	89	00061	1	PI00061-1	SODIUM HYPOCHLORITE FEED PUMP 1 OUTLET PRESSURE	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00070	1	HS00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 IN AUTO	03-PI-03		ACC2101	DI	120VAC					
	89	00070	1	YL00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 RUNNING	03-PI-03		ACC2101	DI	120VAC					
	89	00070	1	YA00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 FAULT	03-PI-03		ACC2101	DI	120VAC					
	89	00070	1	YC00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 START	03-PI-03		ACC2101	DO	120VAC					
	89	00070	1	SC00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 SPEED SETPT	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00070	1	SI00070-1	SODIUM HYPOCHLORITE FEED PUMP 2 SPEED	03-PI-03		ACC2101	AO	4 - 20 mA					
	89	00071	1	PI00071-1	SODIUM HYPOCHLORITE FEED PUMP 2 OUTLET PRESSURE	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00082	1	FI00082-1	FILTER INLET SODIUM HYPOCHLORITE FEED FLOW	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00065	1	FI00065-1	RAW WATER PIPE SODIUM HYPOCHLORITE FEED FLOW	03-PI-03		ACC2101	AI	4 - 20 mA					
	89	00110	1	HS00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 IN AUTO	03-PI-04		ACC2101	DI	120VAC					
	89	00110	1	YL00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 RUNNING	03-PI-04		ACC2101	DI	120VAC					
	89	00110	1	YA00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 FAULT	03-PI-04		ACC2101	DI	120VAC					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	89	00110	1	YC00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 START	03-PI-04		ACC2101	DO	120VAC					
	89	00110	1	SC00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 SPEED SETPT	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00110	1	SI00110-1	SODIUM HYPOCHLORITE FEED PUMP 6 SPEED	03-PI-04		ACC2101	AO	4 - 20 mA					
	89	00111	1	PI00111-1	SODIUM HYPOCHLORITE FEED PUMP 6 OUTLET PRESSURE	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00100	1	HS00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 IN AUTO	03-PI-04		ACC2101	DI	120VAC					
	89	00100	1	YL00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 RUNNING	03-PI-04		ACC2101	DI	120VAC					
	89	00100	1	YA00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 FAULT	03-PI-04		ACC2101	DI	120VAC					
	89	00100	1	YC00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 START	03-PI-04		ACC2101	DO	120VAC					
	89	00100	1	SC00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 SPEED SETPT	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00100	1	SI00100-1	SODIUM HYPOCHLORITE FEED PUMP 5 SPEED	03-PI-04		ACC2101	AO	4 - 20 mA					
	89	00101	1	PI00101-1	SODIUM HYPOCHLORITE FEED PUMP 5 OUTLET PRESSURE	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00090	1	HS00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 IN AUTO	03-PI-04		ACC2101	DI	120VAC					
	89	00090	1	YL00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 RUNNING	03-PI-04		ACC2101	DI	120VAC					
	89	00090	1	YA00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 FAULT	03-PI-04		ACC2101	DI	120VAC					
	89	00090	1	YC00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 START	03-PI-04		ACC2101	DO	120VAC					
	89	00090	1	SC00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 SPEED SETPT	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00090	1	SI00090-1	SODIUM HYPOCHLORITE FEED PUMP 4 SPEED	03-PI-04		ACC2101	AO	4 - 20 mA					
	89	00091	1	PI00091-1	SODIUM HYPOCHLORITE FEED PUMP 4 OUTLET PRESSURE	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00112	1	FI00112-1	BACKWASH PIPE SODIUM HYPOCHLORITE FEED FLOW	03-PI-04		ACC2101	AI	4 - 20 mA					
	89	00095	1	FI00095-1	COMBINED FILTER OUTLET SODIUM HYPOCHLORITE FEED FLOW	03-PI-04		ACC2101	AI	4 - 20 mA					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	00010	3	HS00010-3	RAW WATER SAMPLE PUMP IN AUTO	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	2	YL00010-2	RAW WATER SAMPLE PUMP RUNNING	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	2	YA00010-2	RAW WATER SAMPLE PUMP FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	1	YC00010-1	RAW WATER SAMPLE PUMP START	35-PI-01		35-PLC-9000	DO	120VAC					
	35	00011	1	FI00011-1	DECANT PUMP STATION FLOW	35-PI-01		35-PLC-9000	AI	4 - 20 mA					
	35	00013	3	HS00013-3	DECANT PUMP STATION VALVE IN REMOTE	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00013	1	ZC00013-1	DECANT PUMP STATION VALVE POSITION SETPT	35-PI-01		35-PLC-9000	AO	4 - 20 mA					
	35	00013	1	ZI00013-1	DECANT PUMP STATION VALVE POSITION	35-PI-01		35-PLC-9000	AI	4 - 20 mA					
	35	00013	1	ZIO00013-1	DECANT PUMP STATION VALVE OPENED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00013	1	ZIC00013-1	DECANT PUMP STATION VALVE CLOSED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00013	1	YA00013-1	DECANT PUMP STATION VALVE FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00012	1	FI00012-1	INFILTRATION GALLERY PUMP STATION FLOW	35-PI-01		35-PLC-9000	AI	4 - 20 mA					
	35	00014	3	HS00014-3	INFILTRATION GALLERY PUMP STATION OUTLET VALVE IN AUTO	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00014	1	ZIO00014-3	INFILTRATION GALLERY PUMP STATION OUTLET VALVE OPENED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00014	1	ZIC00014-1	INFILTRATION GALLERY PUMP STATION OUTLET VALVE CLOSED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00014	1	YA00014-1	INFILTRATION GALLERY PUMP STATION OUTLET VALVE FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00014	1	ZC00014-1	INFILTRATION GALLERY PUMP STATION OUTLET VALVE POSITION SETPT	35-PI-01		35-PLC-9000	AO	4 - 20 mA					
	35	00014	1	ZI00014-1	INFILTRATION GALLERY PUMP STATION OUTLET VALVE POSITION	35-PI-01		35-PLC-9000	AI	4 - 20 mA					
	35	00010	3	HS00010-3	INTAKE STRUCTURE VALVE IN AUTO	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	1	ZIO00010-1	INTAKE STRUCTURE VALVE OPENED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	1	ZIC00010-1	INTAKE STRUCTURE VALVE CLOSED	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	1	YA00010-1	INTAKE STRUCTURE VALVE FAULT	35-PI-01		35-PLC-9000	DI	120VAC					
	35	00010	1	ZC000010-1	INTAKE STRUCTURE VALVE OPEN COMMAND	35-PI-01		35-PLC-9000	DO	120VAC					
	35	00010	1	ZCC00010-1	INTAKE STRUCTURE VALVE CLOSE COMMAND	35-PI-01		35-PLC-9000	DO	120VAC					
	35	20010	1	PAL20010-1	FLASH MIX PUMP 2 LOW PRESSURE	35-PI-02		35-PLC-9000	DI	120VAC					
	35	20010	1	PAH20010-1	FLASH MIX PUMP 2 HIGH PRESSURE	35-PI-02		35-PLC-9000	DI	120VAC					
	35	20010	3	HS20010-3	FLASH MIX PUMP 2 IN AUTO	35-PI-02		35-PLC-9000	DI	120VAC					
	35	20010	2	SI20010-2	FLASH MIX PUMP 2 SPEED	35-PI-02		35-PLC-9000	AI	4 - 20 mA					
	35	20010	2	SC20010-2	FLASH MIX PUMP 2 SPEED SETPOINT	35-PI-02		35-PLC-9000	AO	4 - 20 mA					
	35	20010	2	YA20010-2	FLASH MIX PUMP 2 FAULT	35-PI-02		35-PLC-9000	DI	120VAC					
	35	20010	2	YL20010-2	FLASH MIX PUMP 2 RUNNING	35-PI-02		35-PLC-9000	DI	120VAC					
	35	20010	2	YC20010-2	FLASH MIX PUMP 2 START	35-PI-02		35-PLC-9000	DO	120VAC					
	35	10010	1	PAL10010-1	FLASH MIX PUMP 1 LOW PRESSURE	35-PI-02		35-PLC-9000	DI	120VAC					
	35	10010	1	PAH10010-1	FLASH MIX PUMP 1 HIGH PRESSURE	35-PI-02		35-PLC-9000	DI	120VAC					
	35	10010	3	HS10010-3	FLASH MIX PUMP 1 IN AUTO	35-PI-02		35-PLC-9000	DI	120VAC					
	35	10010	2	SI10010-2	FLASH MIX PUMP 1 SPEED	35-PI-02		35-PLC-9000	AI	4 - 20 mA					
	35	10010	2	SC10010-2	FLASH MIX PUMP 1 SPEED SETPOINT	35-PI-02		35-PLC-9000	AO	4 - 20 mA					
	35	10010	2	YA10010-2	FLASH MIX PUMP 1 FAULT	35-PI-02		35-PLC-9000	DI	120VAC					
	35	10010	2	YL10010-2	FLASH MIX PUMP 1 RUNNING	35-PI-02		35-PLC-9000	DI	120VAC					
	35	10010	2	YC10010-2	FLASH MIX PUMP 1 START	35-PI-02		35-PLC-9000	DO	120VAC					
	35	10011	1	AI10011-1	FLASH MIX PUMP 1 COND	35-PI-02		35-PLC-9000	AI	4 - 20 mA					
	35	10012	1	ZC010012-1	FLASH MIX PUMP 1 SOL VALVE OPEN	35-PI-02		35-PLC-9000	DO	120VAC					
	35	20011	1	AI20011-1	FLASH MIX PUMP 2 COND	35-PI-02		35-PLC-9000	AI	4 - 20 mA					
	35	20012	1	ZC020012-1	FLASH MIX PUMP 2 SOL VALVE OPEN	35-PI-02		35-PLC-9000	DO	120VAC					
	35	00020	1	FI00020-1	FLASH MIX FLOW	35-PI-03		35-PLC-9000	AI	4 - 20 mA					
	35	00020	1	FAL00020-1	FLASH MIX LOW FLOW	35-PI-03		35-PLC-9000	DI	120VAC					
	35	00023	1	AI00023-1	RW STREAMING CURRENT	35-PI-04		35-PLC-9000	AI	4 - 20 mA					
	35	20011	3	HS20011-3	RW FLOC INLET BASIN 2 INTAKE VALVE IN REMOTE	35-PI-04		35-PLC-9000	DI	120VAC					
	35	20011	1	ZC20011-1	RW FLOC INLET BASIN 2 INTAKE VALVE POSITION SETPT	35-PI-04		35-PLC-9000	AO	4 - 20 mA					
	35	20011	1	ZI20011-1	RW FLOC INLET BASIN 2 INTAKE VALVE POSITION	35-PI-04		35-PLC-9000	AI	4 - 20 mA					
	35	20011	1	ZIO20011-1	RW FLOC INLET BASIN 2 INTAKE VALVE OPEN	35-PI-04		35-PLC-9000	DI	120VAC					
	35	20011	1	ZIC20011-1	RW FLOC INLET BASIN 2 INTAKE VALVE CLOSED	35-PI-04		35-PLC-9000	DI	120VAC					
	35	20011	1	YA20011-1	RW FLOC INLET BASIN 2 INTAKE VALVE FAULT	35-PI-04		35-PLC-9000	DI	120VAC					
	35	00020	3	HS00020-3	COAGULATED WATER SAMPLE PUMP IN AUTO	35-PI-04		35-PLC-9000	DI	120VAC					
	35	00020	2	YL00020-2	COAGULATED WATER SAMPLE PUMP RUNNING	35-PI-04		35-PLC-9000	DI	120VAC					
	35	00020	2	YA00020-2	COAGULATED WATER SAMPLE PUMP FAULT	35-PI-04		35-PLC-9000	DI	120VAC					
	35	00020	1	YC00020-1	COAGULATED WATER SAMPLE PUMP START	35-PI-04		35-PLC-9000	DO	120VAC					
	35	10011	1	FI10011-1	RW FLOC INLET BASIN 1 FLOW	35-PI-04		35-PLC-9000	AI	4 - 20 mA					
	35	20011	1	FI20011-1	RW FLOC INLET BASIN 2 FLOW	35-PI-04		35-PLC-9000	AI	4 - 20 mA					
	35	10011	3	HS10011-3	RW FLOC INLET BASIN 1 INTAKE VALVE IN REMOTE	35-PI-04		35-PLC-9000	DI	120VAC					
	35	10011	1	ZC10011-1	RW FLOC INLET BASIN 1 INTAKE VALVE POSITION SETPT	35-PI-04		35-PLC-9000	AO	4 - 20 mA					
	35	10011	1	ZI10011-1	RW FLOC INLET BASIN 1 INTAKE VALVE POSITION	35-PI-04		35-PLC-9000	AI	120VAC					
	35	10011	1	ZIO10011-1	RW FLOC INLET BASIN 1 INTAKE VALVE OPEN	35-PI-04		35-PLC-9000	DI	120VAC					
	35	10011	1	ZIC10011-1	RW FLOC INLET BASIN 1 INTAKE VALVE CLOSED	35-PI-04		35-PLC-9000	DI	120VAC					
	35	10011	1	YA10011-1	RW FLOC INLET BASIN 1 INTAKE VALVE FAULT	35-PI-04		35-PLC-9000	DI	120VAC					
	30	11010	3	HS11010-3	FLOCCULATOR 1A IN REMOTE	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11010	2	YL11010-2	FLOCCULATOR 1A RUNNING	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11010	2	YA11010-2	FLOCCULATOR 1A FAULT	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11010	2	SI11010-2	FLOCCULATOR 1A SPEED	35-PI-05		35-PLC-9000	AI	4 - 20 mA					
	30	11010	2	SC11010-2	FLOCCULATOR 1A SPEED SETPOINT	35-PI-05		35-PLC-9000	AO	4 - 20 mA					
	30	11010	1	YC11010-1	FLOCCULATOR 1A START	35-PI-05		35-PLC-9000	DO	120VAC					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	30	11020	3	HS11020-3	FLOCCULATOR 1B IN REMOTE	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11020	2	YL11020-2	FLOCCULATOR 1B RUNNING	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11020	2	YA11020-2	FLOCCULATOR 1B FAULT	35-PI-05		35-PLC-9000	DI	120VAC					
	30	11020	2	SI11020-2	FLOCCULATOR 1B SPEED	35-PI-05		35-PLC-9000	AI	4 - 20 mA					
	30	11020	2	SC11020-2	FLOCCULATOR 1B SPEED SETPOINT	35-PI-05		35-PLC-9000	AO	4 - 20 mA					
	30	11020	1	YC11020-1	FLOCCULATOR 1B START	35-PI-05		35-PLC-9000	DO	120VAC					
	30	12010	3	HS12010-3	FLOCCULATOR 2A IN REMOTE	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12010	2	YL12010-2	FLOCCULATOR 2A RUNNING	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12010	2	YA12010-2	FLOCCULATOR 2A FAULT	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12010	2	SI12010-2	FLOCCULATOR 2A SPEED	35-PI-06		35-PLC-9000	AI	4 - 20 mA					
	30	12010	2	SC12010-2	FLOCCULATOR 2A SPEED SETPOINT	35-PI-06		35-PLC-9000	AO	4 - 20 mA					
	30	12010	1	YC12010-1	FLOCCULATOR 2A START	35-PI-06		35-PLC-9000	DO	120VAC					
	30	12020	3	HS12020-3	FLOCCULATOR 2B IN REMOTE	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12020	2	YL12020-2	FLOCCULATOR 2B RUNNING	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12020	2	YA12020-2	FLOCCULATOR 2B FAULT	35-PI-06		35-PLC-9000	DI	120VAC					
	30	12020	2	SI12020-2	FLOCCULATOR 2B SPEED	35-PI-06		35-PLC-9000	AI	4 - 20 mA					
	30	12020	2	SC12020-2	FLOCCULATOR 2B SPEED SETPOINT	35-PI-06		35-PLC-9000	AO	4 - 20 mA					
	30	12020	1	YC12020-1	FLOCCULATOR 2B START	35-PI-06		35-PLC-9000	DO	120VAC					
	30	13010	3	HS13010-3	FLOCCULATOR 3A IN REMOTE	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13010	2	YL13010-2	FLOCCULATOR 3A RUNNING	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13010	2	YA13010-2	FLOCCULATOR 3A FAULT	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13010	2	SI13010-2	FLOCCULATOR 3A SPEED	35-PI-07		35-PLC-9000	AI	4 - 20 mA					
	30	13010	2	SC13010-2	FLOCCULATOR 3A SPEED SETPOINT	35-PI-07		35-PLC-9000	AO	4 - 20 mA					
	30	13010	1	YC13010-1	FLOCCULATOR 3A START	35-PI-07		35-PLC-9000	DO	120VAC					
	30	13020	3	HS13020-3	FLOCCULATOR 3B IN REMOTE	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13020	2	YL13020-2	FLOCCULATOR 3B RUNNING	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13020	2	YA13020-2	FLOCCULATOR 3B FAULT	35-PI-07		35-PLC-9000	DI	120VAC					
	30	13020	2	SI13020-2	FLOCCULATOR 3B SPEED	35-PI-07		35-PLC-9000	AI	4 - 20 mA					
	30	13020	2	SC13020-2	FLOCCULATOR 3B SPEED SETPOINT	35-PI-07		35-PLC-9000	AO	4 - 20 mA					
	30	13020	1	YC13020-1	FLOCCULATOR 3B START	35-PI-07		35-PLC-9000	DO	120VAC					
	30	21010	3	HS21010-3	FLOCCULATOR 1A IN REMOTE	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21010	2	YL21010-2	FLOCCULATOR 1A RUNNING	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21010	2	YA21010-2	FLOCCULATOR 1A FAULT	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21010	2	SI21010-2	FLOCCULATOR 1A SPEED	35-PI-08		35-PLC-9000	AI	4 - 20 mA					
	30	21010	2	SC21010-2	FLOCCULATOR 1A SPEED SETPOINT	35-PI-08		35-PLC-9000	AO	4 - 20 mA					
	30	21010	1	YC21010-1	FLOCCULATOR 1A START	35-PI-08		35-PLC-9000	DO	120VAC					
	30	21020	3	HS21020-3	FLOCCULATOR 1B IN REMOTE	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21020	2	YL21020-2	FLOCCULATOR 1B RUNNING	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21020	2	YA21020-2	FLOCCULATOR 1B FAULT	35-PI-08		35-PLC-9000	DI	120VAC					
	30	21020	2	SI21020-2	FLOCCULATOR 1B SPEED	35-PI-08		35-PLC-9000	AI	4 - 20 mA					
	30	21020	2	SC21020-2	FLOCCULATOR 1B SPEED SETPOINT	35-PI-08		35-PLC-9000	AO	4 - 20 mA					
	30	21020	1	YC21020-1	FLOCCULATOR 1B START	35-PI-08		35-PLC-9000	DO	120VAC					
	30	22010	3	HS22010-3	FLOCCULATOR 2A IN REMOTE	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22010	2	YL22010-2	FLOCCULATOR 2A RUNNING	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22010	2	YA22010-2	FLOCCULATOR 2A FAULT	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22010	2	SI22010-2	FLOCCULATOR 2A SPEED	35-PI-09		35-PLC-9000	AI	4 - 20 mA					
	30	22010	2	SC22010-2	FLOCCULATOR 2A SPEED SETPOINT	35-PI-09		35-PLC-9000	AO	4 - 20 mA					
	30	22010	1	YC22010-1	FLOCCULATOR 2A START	35-PI-09		35-PLC-9000	DO	120VAC					
	30	22020	3	HS22020-3	FLOCCULATOR 2B IN REMOTE	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22020	2	YL22020-2	FLOCCULATOR 2B RUNNING	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22020	2	YA22020-2	FLOCCULATOR 2B FAULT	35-PI-09		35-PLC-9000	DI	120VAC					
	30	22020	2	SI22020-2	FLOCCULATOR 2B SPEED	35-PI-09		35-PLC-9000	AI	4 - 20 mA					
	30	22020	2	SC22020-2	FLOCCULATOR 2B SPEED SETPOINT	35-PI-09		35-PLC-9000	AO	4 - 20 mA					
	30	22020	1	YC22020-1	FLOCCULATOR 2B START	35-PI-09		35-PLC-9000	DO	120VAC					
	30	23010	3	HS23010-3	FLOCCULATOR 3A IN REMOTE	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23010	2	YL23010-2	FLOCCULATOR 3A RUNNING	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23010	2	YA23010-2	FLOCCULATOR 3A FAULT	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23010	2	SI23010-2	FLOCCULATOR 3A SPEED	35-PI-10		35-PLC-9000	AI	4 - 20 mA					
	30	23010	2	SC23010-2	FLOCCULATOR 3A SPEED SETPOINT	35-PI-10		35-PLC-9000	AO	4 - 20 mA					
	30	23010	1	YC23010-1	FLOCCULATOR 3A START	35-PI-10		35-PLC-9000	DO	120VAC					
	30	23020	3	HS23020-3	FLOCCULATOR 3B IN REMOTE	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23020	2	YL23020-2	FLOCCULATOR 3B RUNNING	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23020	2	YA23020-2	FLOCCULATOR 3B FAULT	35-PI-10		35-PLC-9000	DI	120VAC					
	30	23020	2	SI23020-2	FLOCCULATOR 3B SPEED	35-PI-10		35-PLC-9000	AI	4 - 20 mA					
	30	23020	2	SC23020-2	FLOCCULATOR 3B SPEED SETPOINT	35-PI-10		35-PLC-9000	AO	4 - 20 mA					
	30	23020	1	YC23020-1	FLOCCULATOR 3B START	35-PI-10		35-PLC-9000	DO	120VAC					
	40	10001	1	ZC010001-1	UTILITY WATER SYSTEM VALVE OPEN	35-PI-11		35-PLC-9000	DO	120VAC					
	40	10010	3	HS10010-3	SOLIDS COLLECTOR 1A IN AUTO	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10010	2	YL10010-2	SOLIDS COLLECTOR 1A RUNNING	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10010	2	YA10010-2	SOLIDS COLLECTOR 1A FAULT	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10010	1	YC10010-1	SOLIDS COLLECTOR 1A START	35-PI-11		35-PLC-9000	DO	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	40	10010	2	SC10010-2	SOLIDS COLLECTOR 1A SPEED SETPT	35-PI-11		35-PLC-9000	AO	4 - 20 mA					
	40	10010	2	SI10010-2	SOLIDS COLLECTOR 1A SPEED	35-PI-11		35-PLC-9000	AI	4 - 20 mA					
	40	10011	3	HS10011-3	SED BASIN 1A SOLIDS DISCHARGE VALVE IN REMOTE	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10011	1	ZC010011-1	SED BASIN 1A SOLIDS DISCHARGE VALVE OPEN COMMAND	35-PI-11		35-PLC-9000	DO	120VAC					
	40	10011	1	ZCC10011-1	SED BASIN 1A SOLIDS DISCHARGE VALVE CLOSE COMMAND	35-PI-11		35-PLC-9000	DO	120VAC					
	40	10011	1	ZIO10011-1	SED BASIN 1A SOLIDS DISCHARGE VALVE OPEN	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10011	1	ZIC10011-1	SED BASIN 1A SOLIDS DISCHARGE VALVE CLOSED	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10011	1	YA10011-1	SED BASIN 1A SOLIDS DISCHARGE VALVE FAULT	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10004	1	AI10004-1	SED BASIN 1A PLATE SETTLER DISCHARGE TURBIDITY	35-PI-11		35-PLC-9000	AI	4 - 20 mA					
	40	10012	3	HS10012-3	SED BASIN 1A FILTER INFLUENT VALVE IN REMOTE	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10012	1	ZIO10012-1	SED BASIN 1A FILTER INFLUENT VALVE OPENED	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10012	1	ZIC10012-1	SED BASIN 1A FILTER INFLUENT VALVE CLOSED	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10012	1	YA10012-1	SED BASIN 1A FILTER INFLUENT VALVE FAULT	35-PI-11		35-PLC-9000	DI	120VAC					
	40	10012	1	ZC10012-1	SED BASIN 1A FILTER INFLUENT VALVE POSITION SETPT	35-PI-11		35-PLC-9000	AO	4 - 20 mA					
	40	10012	1	ZI10012-1	SED BASIN 1A FILTER INFLUENT VALVE POSITION	35-PI-11		35-PLC-9000	AI	4 - 20 mA					
	40	10020	3	HS10020-3	SOLIDS COLLECTOR 1B IN AUTO	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10020	2	YL10020-2	SOLIDS COLLECTOR 1B RUNNING	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10020	2	YA10020-2	SOLIDS COLLECTOR 1B FAULT	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10020	1	YC10020-1	SOLIDS COLLECTOR 1B START	35-PI-12		35-PLC-9000	DO	120VAC					
	40	10020	2	SC10020-2	SOLIDS COLLECTOR 1B SPEED SETPT	35-PI-12		35-PLC-9000	AO	4 - 20 mA					
	40	10020	2	SI10020-2	SOLIDS COLLECTOR 1B SPEED	35-PI-12		35-PLC-9000	AI	4 - 20 mA					
	40	10021	3	HS10021-3	SED BASIN 1B SOLIDS DISCHARGE VALVE IN REMOTE	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10021	1	ZC010021-1	SED BASIN 1B SOLIDS DISCHARGE VALVE OPEN COMMAND	35-PI-12		35-PLC-9000	DO	120VAC					
	40	10021	1	ZCC10021-1	SED BASIN 1B SOLIDS DISCHARGE VALVE CLOSE COMMAND	35-PI-12		35-PLC-9000	DO	120VAC					
	40	10021	1	ZIO10021-1	SED BASIN 1B SOLIDS DISCHARGE VALVE OPEN	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10021	1	ZIC10021-1	SED BASIN 1B SOLIDS DISCHARGE VALVE CLOSED	35-PI-12		35-PLC-9000	DI	120VAC					
	40	10021	1	YA10021-1	SED BASIN 1B SOLIDS DISCHARGE VALVE FAULT	35-PI-12		35-PLC-9000	DI	120VAC					
	35	00010	1	HS00010-1	FILTER INFLUENT CHANNEL AGITATION PUMP IN AUTO	35-PI-15		35-PLC-9000	DI	120VAC					
	40	20001	1	ZC020001-1	UTILITY WATER SYSTEM VALVE OPEN	35-PI-13		35-PLC-9000	DO	120VAC					
	40	20010	3	HS20010-3	SOLIDS COLLECTOR 2A IN AUTO	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20010	2	YL20010-2	SOLIDS COLLECTOR 2A RUNNING	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20010	2	YA20010-2	SOLIDS COLLECTOR 2A FAULT	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20010	1	YC20010-1	SOLIDS COLLECTOR 2A START	35-PI-13		35-PLC-9000	DO	120VAC					
	40	20010	2	SC20010-2	SOLIDS COLLECTOR 2A SPEED SETPT	35-PI-13		35-PLC-9000	AO	4 - 20 mA					
	40	20010	2	SI20010-2	SOLIDS COLLECTOR 2A SPEED	35-PI-13		35-PLC-9000	AI	4 - 20 mA					
	40	20011	3	HS20011-3	SED BASIN 2A SOLIDS DISCHARGE VALVE IN REMOTE	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20011	1	ZC020011-1	SED BASIN 2A SOLIDS DISCHARGE VALVE OPEN COMMAND	35-PI-13		35-PLC-9000	DO	120VAC					
	40	20011	1	ZCC20011-1	SED BASIN 2A SOLIDS DISCHARGE VALVE CLOSE COMMAND	35-PI-13		35-PLC-9000	DO	120VAC					
	40	20011	1	ZIO20011-1	SED BASIN 2A SOLIDS DISCHARGE VALVE OPEN	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20011	1	ZIC20011-1	SED BASIN 2A SOLIDS DISCHARGE VALVE CLOSED	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20011	1	YA20011-1	SED BASIN 2A SOLIDS DISCHARGE VALVE FAULT	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20004	1	AI20004-1	SED BASIN 2A PLATE SETTLER DISCHARGE TURBIDITY	35-PI-13		35-PLC-9000	AI	4 - 20 mA					
	40	20012	3	HS20012-3	SED BASIN 2A FILTER INFLUENT VALVE IN REMOTE	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20012	1	ZIO20012-1	SED BASIN 2A FILTER INFLUENT VALVE OPENED	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20012	1	ZIC20012-1	SED BASIN 2A FILTER INFLUENT VALVE CLOSED	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20012	1	YA20012-1	SED BASIN 2A FILTER INFLUENT VALVE FAULT	35-PI-13		35-PLC-9000	DI	120VAC					
	40	20012	1	ZC20012-1	SED BASIN 2A FILTER INFLUENT VALVE POSITION SETPT	35-PI-13		35-PLC-9000	AO	4 - 20 mA					
	40	20012	1	ZI20012-1	SED BASIN 2A FILTER INFLUENT VALVE POSITION	35-PI-13		35-PLC-9000	AI	4 - 20 mA					
	40	20020	3	HS20020-3	SOLIDS COLLECTOR 2B IN AUTO	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20020	2	YL20020-2	SOLIDS COLLECTOR 2B RUNNING	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20020	2	YA20020-2	SOLIDS COLLECTOR 2B FAULT	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20020	1	YC20020-1	SOLIDS COLLECTOR 2B START	35-PI-14		35-PLC-9000	DO	120VAC					
	40	20020	2	SC20020-2	SOLIDS COLLECTOR 2B SPEED SETPT	35-PI-14		35-PLC-9000	AO	4 - 20 mA					
	40	20020	2	SI20020-2	SOLIDS COLLECTOR 2B SPEED	35-PI-14		35-PLC-9000	AI	4 - 20 mA					
	40	20021	3	HS20021-3	SED BASIN 2B SOLIDS DISCHARGE VALVE IN REMOTE	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20021	1	ZC020021-1	SED BASIN 2B SOLIDS DISCHARGE VALVE OPEN COMMAND	35-PI-14		35-PLC-9000	DO	120VAC					
	40	20021	1	ZCC20021-1	SED BASIN 2B SOLIDS DISCHARGE VALVE CLOSE COMMAND	35-PI-14		35-PLC-9000	DO	120VAC					
	40	20021	1	ZIO20021-1	SED BASIN 2B SOLIDS DISCHARGE VALVE OPEN	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20021	1	ZIC20021-1	SED BASIN 2B SOLIDS DISCHARGE VALVE CLOSED	35-PI-14		35-PLC-9000	DI	120VAC					
	40	20021	1	YA20021-1	SED BASIN 2B SOLIDS DISCHARGE VALVE FAULT	35-PI-14		35-PLC-9000	DI	120VAC					
	35	00016	1	LI00016-1	FILTER INFLUENT CHANNEL LEVEL	35-PI-15		35-PLC-9000	AI	4 - 20 mA					
	35	00110	3	HS00110-3	COMBINED FILTERED WATER SAMPLE PUMP IN AUTO	35-PI-22		35-PLC-9000	DI	120VAC					
	35	00110	2	YL00110-2	COMBINED FILTERED WATER SAMPLE PUMP RUNNING	35-PI-22		35-PLC-9000	DI	120VAC					
	35	00110	2	YA00110-2	COMBINED FILTERED WATER SAMPLE PUMP FAULT	35-PI-22		35-PLC-9000	DI	120VAC					
	35	00110	1	YC00110-1	COMBINED FILTERED WATER SAMPLE PUMP START	35-PI-22		35-PLC-9000	DO	120VAC					
	35	00112	1	PI00112-1	COMBINED FILTERED WATER SAMPLE LINE PRESSURE	35-PI-22		35-PLC-9000	AI	4 - 20 mA					
	35	00151	1	AI00151-1	COMBINED FILTERED WATER SAMPLE LINE TURBIDITY	35-PI-22		35-PLC-9000	AI	4 - 20 mA					
	35	00018	1	FI00018-1	BW HEADER FLOW	35-PI-23		35-PLC-9000	AI	4 - 20 mA					
	35	00019	3	HS00019-3	BW HEADER DOWNSTREAM VALVE IN REMOTE	35-PI-23		35-PLC-9000	DI	120VAC					
	35	00019	1	ZC00019-1	BW HEADER DOWNSTREAM VALVE POSITION SETPT	35-PI-23		35-PLC-9000	DO	120VAC					
	35	00019	1	ZI00019-1	BW HEADER DOWNSTREAM VALVE POSITION	35-PI-23		35-PLC-9000	DO	120VAC					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	00019	1	ZIO00019-1	BW HEADER DOWNSTREAM VALVE OPEN	35-PI-23		35-PLC-9000	DI	120VAC					
	35	00019	1	ZIC00019-1	BW HEADER DOWNSTREAM VALVE CLOSED	35-PI-23		35-PLC-9000	DI	120VAC					
	35	00019	1	YA00019-1	BW HEADER DOWNSTREAM VALVE FAULT	35-PI-23		35-PLC-9000	DI	120VAC					
	35	00021	1	AI00021-1	FTW SAMPLE LINE TURBIDITY	35-PI-23		35-PLC-9000	AI	4 - 20 mA					
	84	00010	3	HS00010-3	NEAT PEA MIXING PUMP IN AUTO	35-PI-28		35-PLC-9000	DI	120VAC					
	84	00010	2	YL00010-2	NEAT PEA MIXING PUMP RUNNING	35-PI-28		35-PLC-9000	DI	120VAC					
	84	00010	2	YA00010-2	NEAT PEA MIXING PUMP FAULT	35-PI-28		35-PLC-9000	DI	120VAC					
	84	00010	1	YC00010-1	NEAT PEA MIXING PUMP START	35-PI-28		35-PLC-9000	DO	120VAC					
	84	00010	1	PAH00010-1	NEAT PEA MIXING PUMP HIGH PRESSURE	35-PI-28		35-PLC-9000	DI	120VAC					
	84	00013	1	WI00013-1	NEAT PEA STORAGE TANK WEIGHT	35-PI-28		35-PLC-9000	AI	4 - 20 mA					
	84	10010	3	HS10010-3	POLYMER BLENDING UNIT 1 IN AUTO	35-PI-28		35-PLC-9000	DI	120VAC					
	84	10010	1	YL10010-1	POLYMER BLENDING UNIT 1 RUNNING	35-PI-28		35-PLC-9000	DI	120VAC					
	84	10010	1	YA10010-1	POLYMER BLENDING UNIT 1 FAULT	35-PI-28		35-PLC-9000	DI	120VAC					
	84	10010	1	SI10010-1	POLYMER BLENDING UNIT 1 SPEED	35-PI-28		35-PLC-9000	AI	4 - 20 mA					
	84	10010	1	SC10010-1	POLYMER BLENDING UNIT 1 SPEED SETPOINT	35-PI-28		35-PLC-9000	AO	4 - 20 mA					
	84	10010	1	YC10010-1	POLYMER BLENDING UNIT 1 START	35-PI-28		35-PLC-9000	DO	120VAC					
	84	20010	3	HS20010-3	POLYMER BLENDING UNIT 2 IN AUTO	35-PI-28		35-PLC-9000	DI	120VAC					
	84	20010	1	YL20010-1	POLYMER BLENDING UNIT 2 RUNNING	35-PI-28		35-PLC-9000	DI	120VAC					
	84	20010	1	YA20010-1	POLYMER BLENDING UNIT 2 FAULT	35-PI-28		35-PLC-9000	DI	120VAC					
	84	20010	1	SI20010-1	POLYMER BLENDING UNIT 2 SPEED	35-PI-28		35-PLC-9000	AI	4 - 20 mA					
	84	20010	1	SC20010-1	POLYMER BLENDING UNIT 2 SPEED SETPOINT	35-PI-28		35-PLC-9000	AO	4 - 20 mA					
	84	00014	1	FAL00014-1	POLYMER BLENDING UNIT EYEWASH STATION ACTIVATED	35-PI-28		35-PLC-9000	DI	120VAC					
	84	00021	1	LI00021-1	NEAT PEA BATCH TANK LEVEL	35-PI-29		35-PLC-9000	AI	4 - 20 mA					
	84	00020	3	HS00020-3	PEA FEED PUMP 1 IN AUTO	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00020	1	YL00020-1	PEA FEED PUMP 1 RUNNING	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00020	1	YA00020-1	PEA FEED PUMP 1 FAULT	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00020	1	SI00020-1	PEA FEED PUMP 1 SPEED	35-PI-29		35-PLC-9000	AI	4 - 20 mA					
	84	00020	1	SC00020-1	PEA FEED PUMP 1 SPEED SETPOINT	35-PI-29		35-PLC-9000	AO	4 - 20 mA					
	84	00020	1	YC00020-1	PEA FEED PUMP 1 START	35-PI-29		35-PLC-9000	DO	120VAC					
	84	00021	1	PAH00021-1	PEA FEED PUMP 1 HIGH DISCHARGE PRESSURE	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00030	3	HS00030-3	PEA FEED PUMP 2 IN AUTO	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00030	1	YL00030-1	PEA FEED PUMP 2 RUNNING	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00030	1	YA00030-1	PEA FEED PUMP 2 FAULT	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00030	1	SI00030-1	PEA FEED PUMP 2 SPEED	35-PI-29		35-PLC-9000	AI	4 - 20 mA					
	84	00030	1	SC00030-1	PEA FEED PUMP 2 SPEED SETPOINT	35-PI-29		35-PLC-9000	AO	4 - 20 mA					
	84	00030	1	YC00030-1	PEA FEED PUMP 2 START	35-PI-29		35-PLC-9000	DO	120VAC					
	84	00031	1	PAH00031-1	PEA FEED PUMP 2 HIGH DISCHARGE PRESSURE	35-PI-29		35-PLC-9000	DI	120VAC					
	84	00015	1	FI00015-1	PEA FEED PUMP 1 AND 2 COMBINED FLOW	35-PI-29		35-PLC-9000	AI	4 - 20 mA					
	84	00016	1	ZC000016-1	UTILITY WATER TO PEA FEED PUMP 1 AND 2 VALVE OPEN COMMAND	35-PI-29		35-PLC-9000	DO	120VAC					
	84	00040	3	HS00040-3	PEA FEED PUMP 3 IN AUTO	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00040	1	YL00040-1	PEA FEED PUMP 3 RUNNING	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00040	1	YA00040-1	PEA FEED PUMP 3 FAULT	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00040	1	SI00040-1	PEA FEED PUMP 3 SPEED	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	84	00040	1	SC00040-1	PEA FEED PUMP 3 SPEED SETPOINT	35-PI-30		35-PLC-9000	AO	4 - 20 mA					
	84	00040	1	YC00040-1	PEA FEED PUMP 3 START	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00041	1	PAH00041-1	PEA FEED PUMP 3 HIGH DISCHARGE PRESSURE	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00043	1	ZC000043-1	UTILITY WATER TO PEA FEED PUMP 3 VALVE OPEN COMMAND	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00042	1	FI00042-1	PEA FEED PUMP 3 FLOW	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	84	00050	3	HS00050-3	PEA FEED PUMP 4 IN AUTO	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00050	1	YL00050-1	PEA FEED PUMP 4 RUNNING	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00050	1	YA00050-1	PEA FEED PUMP 4 FAULT	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00050	1	SI00050-1	PEA FEED PUMP 4 SPEED	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	84	00050	1	SC00050-1	PEA FEED PUMP 4 SPEED SETPOINT	35-PI-30		35-PLC-9000	AO	4 - 20 mA					
	84	00050	1	YC00050-1	PEA FEED PUMP 4 START	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00051	1	PAH00051-1	PEA FEED PUMP 4 HIGH DISCHARGE PRESSURE	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00053	1	ZC000053-1	UTILITY WATER TO PEA FEED PUMP 4 VALVE OPEN COMMAND	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00052	1	FI00052-1	PEA FEED PUMP 4 FLOW	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	84	00060	3	HS00060-1	PEA FEED PUMP 5 IN AUTO	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00060	1	YL00060-1	PEA FEED PUMP 5 RUNNING	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00060	1	YA00060-1	PEA FEED PUMP 5 FAULT	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00060	1	SI00060-1	PEA FEED PUMP 5 SPEED	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	84	00060	1	SC00060-1	PEA FEED PUMP 5 SPEED SETPOINT	35-PI-30		35-PLC-9000	AO	4 - 20 mA					
	84	00060	1	YC00060-1	PEA FEED PUMP 5 START	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00061	1	PAH00061-1	PEA FEED PUMP 5 HIGH DISCHARGE PRESSURE	35-PI-30		35-PLC-9000	DI	120VAC					
	84	00063	1	ZC000063-1	UTILITY WATER TO PEA FEED PUMP 5 VALVE OPEN COMMAND	35-PI-30		35-PLC-9000	DO	120VAC					
	84	00062	1	FI00062-1	PEA FEED PUMP 5 FLOW	35-PI-30		35-PLC-9000	AI	4 - 20 mA					
	35	00011	1	LI00011-1	SEDIMENTATION BASIN LEVEL	35-PI-31		35-PLC-9000	AI	4 - 20 mA					
	35	00012	1	FI00012-1	SEDIMENTATION BASIN FLOW	35-PI-31		35-PLC-9000	AI	4 - 20 mA					
	35	00011	1	LAH00011-1	RECYCLE PUMP STATION HIGH LEVEL	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00011	1	LAM00011-1	RECYCLE PUMP STATION MID LEVEL	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00011	1	LAL00011-1	RECYCLE PUMP STATION LOW LEVEL	35-PI-32		35-PLC-9000	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	00050	3	HS00050-3	TREATMENT BUILDING RECYCLE PUMP 1 IN AUTO	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00050	2	YL00050-2	TREATMENT BUILDING RECYCLE PUMP 1 RUNNING	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00050	2	YA00050-2	TREATMENT BUILDING RECYCLE PUMP 1 FAULT	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00050	1	YC00050-1	TREATMENT BUILDING RECYCLE PUMP 1 START	35-PI-32		35-PLC-9000	DO	120VAC					
	35	00050	1	TAH00050-1	TREATMENT BUILDING RECYCLE PUMP 1 HIGH MOTOR WINDING TEMP	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00050	1	MAH00050-1	TREATMENT BUILDING RECYCLE PUMP 1 MOISTURE	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00060	3	HS00060-3	TREATMENT BUILDING RECYCLE PUMP 2 IN AUTO	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00060	2	YL00060-2	TREATMENT BUILDING RECYCLE PUMP 2 RUNNING	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00060	2	YA00060-2	TREATMENT BUILDING RECYCLE PUMP 2 FAULT	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00060	1	YC00060-1	TREATMENT BUILDING RECYCLE PUMP 2 START	35-PI-32		35-PLC-9000	DO	120VAC					
	35	00060	1	TAH00060-1	TREATMENT BUILDING RECYCLE PUMP 2 HIGH MOTOR WINDING TEMP	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00060	1	MAH00060-1	TREATMENT BUILDING RECYCLE PUMP 2 MOISTURE	35-PI-32		35-PLC-9000	DI	120VAC					
	35	00101	1	LAH00101-1	SUMP PUMP STATION HIGH LEVEL	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00101	1	LAM00101-1	SUMP PUMP STATION MID LEVEL	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00101	1	LAL00101-1	SUMP PUMP STATION LOW LEVEL	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00100	3	HS00100-3	TREATMENT BUILDING DRAINAGE PUMP 2 IN AUTO	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00100	2	YL00100-2	TREATMENT BUILDING DRAINAGE PUMP 2 RUNNING	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00100	2	YA00100-2	TREATMENT BUILDING DRAINAGE PUMP 2 FAULT	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00100	1	YC00100-1	TREATMENT BUILDING DRAINAGE PUMP 2 START	35-PI-33		35-PLC-9000	DO	120VAC					
	35	00100	1	TAH00100-1	TREATMENT BUILDING DRAINAAGE PUMP 2 HIGH MOTOR WINDING TEMP	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00100	1	MAH00100-1	TREATMENT BUILDING DRAINAGE PUMP 2 MOISTURE	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00110	3	HS00110-3	TREATMENT BUILDING DRAINAGE PUMP 3 IN AUTO	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00110	2	YL00110-2	TREATMENT BUILDING DRAINAGE PUMP 3 RUNNING	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00110	2	YA00110-2	TREATMENT BUILDING DRAINAGE PUMP 3 FAULT	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00110	1	YC00110-1	TREATMENT BUILDING DRAINAGE PUMP 3 START	35-PI-33		35-PLC-9000	DO	120VAC					
	35	00110	1	TAH00110-1	TREATMENT BUILDING DRAINAGE PUMP 3 HIGH MOTOR WINDING TEMP	35-PI-33		35-PLC-9000	DI	120VAC					
	35	00110	1	MAH00110-1	TREATMENT BUILDING DRAINAGE PUMP 3 MOISTURE	35-PI-33		35-PLC-9000	DI	120VAC					
	35	10055	1	FI10055-1	COMBINED FTW HEADER FLOW	35-PI-34		35-PLC-9000	AI	4 - 20 mA					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	10131	1	AI10131-1	FILTER 1 FILTERED WATER TURBIDITY	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10141	1	AI10141-1	FILTER 1 FILTERED WATER PARTICLE COUNT	35-PI-16		35-PLC-9001	ASCII	RS 485					
	35	10031	3	HS10031-3	FILTER 1 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10031	1	ZCO10031-1	FILTER 1 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10031	1	ZCC10031-1	FILTER 1 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10031	1	ZIO10031-1	FILTER 1 BACKWASH TO FILTER VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10031	1	ZIC10031-1	FILTER 1 BACKWASH TO FILTER VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10031	1	YA10031-1	FILTER 1 BACKWASH TO FILTER VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10011	3	HS10011-3	FILTER 1 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10011	1	ZCO10011-1	FILTER 1 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10011	1	ZCC10011-1	FILTER 1 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10011	1	ZIO10011-1	FILTER 1 SW TO UPPER GULLET VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10011	1	ZIC10011-1	FILTER 1 SW TO UPPER GULLET VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10011	1	YA10011-1	FILTER 1 SW TO UPPER GULLET VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10061	3	HS10061-3	FILTER 1 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10061	1	ZCO10061-1	FILTER 1 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10061	1	ZCC10061-1	FILTER 1 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-16		35-PLC-9001	DO	120VAC					
	35	10061	1	ZIO10061-1	FILTER 1 BA TO LOWER GULLET VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10061	1	ZIC10061-1	FILTER 1 BA TO LOWER GULLET VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10061	1	YA10061-1	FILTER 1 BA TO LOWER GULLET VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10041	3	HS10041-3	FILTER 1 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10041	1	ZIO10041-1	FILTER 1 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10041	1	ZIC10041-1	FILTER 1 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10041	1	ZI10041-1	FILTER 1 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10041	1	ZC10041-1	FILTER 1 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-16		35-PLC-9001	AO	4 - 20 mA					
	35	10041	1	YA10041-1	FILTER 1 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10111	1	LI10111-1	FILTER 1 BW TROUGH LEVEL	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10042	1	PI10042-1	FILTER 1 FTW PRESSURE	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10021	3	HS10021-3	FILTER 1 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10021	1	ZIO10021-1	FILTER 1 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10021	1	ZIC10021-1	FILTER 1 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10021	1	ZI10021-1	FILTER 1 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10021	1	ZC10021-1	FILTER 1 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-16		35-PLC-9001	AO	4 - 20 mA					
	35	10021	1	YA10021-1	FILTER 1 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10051	3	HS10051-3	FILTER 1 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10010	1	FI10010-1	FILTER 1 FW TO COMBINED FILTER WATER FLOW	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10051	1	ZIO10051-1	FILTER 1 FTW TO FTW HEADER VALVE OPEN	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10051	1	ZIC10051-1	FILTER 1 FTW TO FTW HEADER VALVE CLOSED	35-PI-16		35-PLC-9001	DI	120VAC					
	35	10051	1	ZI10051-1	FILTER 1 FTW TO FTW HEADER VALVE POSITION	35-PI-16		35-PLC-9001	AI	4 - 20 mA					
	35	10051	1	ZC10051-1	FILTER 1 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-16		35-PLC-9001	AO	4 - 20 mA					
	35	10051	1	YA10051-1	FILTER 1 FTW TO FTW HEADER VALVE FAULT	35-PI-16		35-PLC-9001	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	20131	1	AI20131-1	FILTER 2 FILTERED WATER TURBIDITY	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20141	1	AI20141-1	FILTER 2 FILTERED WATER PARTICLE COUNT	35-PI-17		35-PLC-9002	ASCII	RS 485					
	35	20031	3	HS20031-3	FILTER 2 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20031	1	ZCO20031-1	FILTER 2 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20031	1	ZCC20031-1	FILTER 2 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20031	1	ZIO20031-1	FILTER 2 BACKWASH TO FILTER VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20031	1	ZIC20031-1	FILTER 2 BACKWASH TO FILTER VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20031	1	YA20031-1	FILTER 2 BACKWASH TO FILTER VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20011	3	HS20011-3	FILTER 2 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20011	1	ZCO20011-1	FILTER 2 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20011	1	ZCC20011-1	FILTER 2 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20011	1	ZIO20011-1	FILTER 2 SW TO UPPER GULLET VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20011	1	ZIC20011-1	FILTER 2 SW TO UPPER GULLET VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20011	1	YA20011-1	FILTER 2 SW TO UPPER GULLET VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20061	3	HS20061-3	FILTER 2 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20061	1	ZCO20061-1	FILTER 2 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20061	1	ZCC20061-1	FILTER 2 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-17		35-PLC-9002	DO	120VAC					
	35	20061	1	ZIO20061-1	FILTER 2 BA TO LOWER GULLET VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20061	1	ZIC20061-1	FILTER 2 BA TO LOWER GULLET VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20061	1	YA20061-1	FILTER 2 BA TO LOWER GULLET VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20041	3	HS20041-3	FILTER 2 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20041	1	ZIO20041-1	FILTER 2 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20041	1	ZIC20041-1	FILTER 2 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20041	1	ZI20041-1	FILTER 2 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20041	1	ZC20041-1	FILTER 2 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-17		35-PLC-9002	AO	4 - 20 mA					
	35	20041	1	YA20041-1	FILTER 2 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20111	1	LI20111-1	FILTER 2 BW TROUGH LEVEL	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20042	1	PI20042-1	FILTER 2 FTW PRESSURE	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20021	3	HS20021-3	FILTER 2 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20021	1	ZIO20021-1	FILTER 2 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20021	1	ZIC20021-1	FILTER 2 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20021	1	ZI20021-1	FILTER 2 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20021	1	ZC20021-1	FILTER 2 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-17		35-PLC-9002	AO	4 - 20 mA					
	35	20021	1	YA20021-1	FILTER 2 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20051	3	HS20051-3	FILTER 2 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20020	1	FI20020-1	FILTER 2 FW TO COMBINED FILTER WATER FLOW	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20051	1	ZIO20051-1	FILTER 2 FTW TO FTW HEADER VALVE OPEN	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20051	1	ZIC20051-1	FILTER 2 FTW TO FTW HEADER VALVE CLOSED	35-PI-17		35-PLC-9002	DI	120VAC					
	35	20051	1	ZI20051-1	FILTER 2 FTW TO FTW HEADER VALVE POSITION	35-PI-17		35-PLC-9002	AI	4 - 20 mA					
	35	20051	1	ZC20051-1	FILTER 2 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-17		35-PLC-9002	AO	4 - 20 mA					
	35	20051	1	YA20051-1	FILTER 2 FTW TO FTW HEADER VALVE FAULT	35-PI-17		35-PLC-9002	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	30131	1	AI30131-1	FILTER 3 FILTERED WATER TURBIDITY	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30141	1	AI30141-1	FILTER 3 FILTERED WATER PARTICLE COUNT	35-PI-18		35-PLC-9003	ASCII	RS 485					
	35	30031	3	HS30031-3	FILTER 3 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30031	1	ZCO30031-1	FILTER 3 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30031	1	ZCC30031-1	FILTER 3 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30031	1	ZIO30031-1	FILTER 3 BACKWASH TO FILTER VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30031	1	ZIC30031-1	FILTER 3 BACKWASH TO FILTER VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30031	1	YA30031-1	FILTER 3 BACKWASH TO FILTER VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30011	3	HS30011-3	FILTER 3 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30011	1	ZCO30011-1	FILTER 3 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30011	1	ZCC30011-1	FILTER 3 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30011	1	ZIO30011-1	FILTER 3 SW TO UPPER GULLET VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30011	1	ZIC30011-1	FILTER 3 SW TO UPPER GULLET VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30011	1	YA30011-1	FILTER 3 SW TO UPPER GULLET VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30061	3	HS30061-3	FILTER 3 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30061	1	ZCO30061-1	FILTER 3 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30061	1	ZCC30061-1	FILTER 3 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-18		35-PLC-9003	DO	120VAC					
	35	30061	1	ZIO30061-1	FILTER 3 BA TO LOWER GULLET VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30061	1	ZIC30061-1	FILTER 3 BA TO LOWER GULLET VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30061	1	YA30061-1	FILTER 3 BA TO LOWER GULLET VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30041	3	HS30041-3	FILTER 3 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30041	1	ZIO30041-1	FILTER 3 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30041	1	ZIC30041-1	FILTER 3 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30041	1	ZI30041-1	FILTER 3 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30041	1	ZC30041-1	FILTER 3 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-18		35-PLC-9003	AO	4 - 20 mA					
	35	30041	1	YA30041-1	FILTER 3 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30111	1	LI30111-1	FILTER 3 BW TROUGH LEVEL	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30042	1	PI30042-1	FILTER 3 FTW PRESSURE	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30021	3	HS30021-3	FILTER 3 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30021	1	ZIO30021-1	FILTER 3 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30021	1	ZIC30021-1	FILTER 3 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30021	1	ZI30021-1	FILTER 3 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30021	1	ZC30021-1	FILTER 3 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-18		35-PLC-9003	AO	4 - 20 mA					
	35	30021	1	YA30021-1	FILTER 3 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30051	3	HS30051-3	FILTER 3 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30030	1	FI30030-1	FILTER 3 FW TO COMBINED FILTER WATER FLOW	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30051	1	ZIO30051-1	FILTER 3 FTW TO FTW HEADER VALVE OPEN	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30051	1	ZIC30051-1	FILTER 3 FTW TO FTW HEADER VALVE CLOSED	35-PI-18		35-PLC-9003	DI	120VAC					
	35	30051	1	ZI30051-1	FILTER 3 FTW TO FTW HEADER VALVE POSITION	35-PI-18		35-PLC-9003	AI	4 - 20 mA					
	35	30051	1	ZC30051-1	FILTER 3 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-18		35-PLC-9003	AO	4 - 20 mA					
	35	30051	1	YA30051-1	FILTER 3 FTW TO FTW HEADER VALVE FAULT	35-PI-18		35-PLC-9003	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	40131	1	AI40131-1	FILTER 4 FILTERED WATER TURBIDITY	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40141	1	AI40141-1	FILTER 4 FILTERED WATER PARTICLE COUNT	35-PI-19		35-PLC-9004	ASCII	RS 485					
	35	40031	3	HS40031-3	FILTER 4 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40031	1	ZCO40031-1	FILTER 4 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40031	1	ZCC40031-1	FILTER 4 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40031	1	ZIO40031-1	FILTER 4 BACKWASH TO FILTER VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40031	1	ZIC40031-1	FILTER 4 BACKWASH TO FILTER VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40031	1	YA40031-1	FILTER 4 BACKWASH TO FILTER VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40011	3	HS40011-3	FILTER 4 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40011	1	ZCO40011-1	FILTER 4 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40011	1	ZCC40011-1	FILTER 4 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40011	1	ZIO40011-1	FILTER 4 SW TO UPPER GULLET VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40011	1	ZIC40011-1	FILTER 4 SW TO UPPER GULLET VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40011	1	YA40011-1	FILTER 4 SW TO UPPER GULLET VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40061	3	HS40061-3	FILTER 4 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40061	1	ZCO40061-1	FILTER 4 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40061	1	ZCC40061-1	FILTER 4 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-19		35-PLC-9004	DO	120VAC					
	35	40061	1	ZIO40061-1	FILTER 4 BA TO LOWER GULLET VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40061	1	ZIC40061-1	FILTER 4 BA TO LOWER GULLET VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40061	1	YA40061-1	FILTER 4 BA TO LOWER GULLET VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40041	3	HS40041-3	FILTER 4 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40041	1	ZIO40041-1	FILTER 4 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40041	1	ZIC40041-1	FILTER 4 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40041	1	ZI40041-1	FILTER 4 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40041	1	ZC40041-1	FILTER 4 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-19		35-PLC-9004	AO	4 - 20 mA					
	35	40041	1	YA40041-1	FILTER 4 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40111	1	LI40111-1	FILTER 4 BW TROUGH LEVEL	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40042	1	PI40042-1	FILTER 4 FTW PRESSURE	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40021	3	HS40021-3	FILTER 4 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40021	1	ZIO40021-1	FILTER 4 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40021	1	ZIC40021-1	FILTER 4 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40021	1	ZI40021-1	FILTER 4 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40021	1	ZC40021-1	FILTER 4 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-19		35-PLC-9004	AO	4 - 20 mA					
	35	40021	1	YA40021-1	FILTER 4 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40051	3	HS40051-3	FILTER 4 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40040	1	FI40040-1	FILTER 4 FW TO COMBINED FILTER WATER FLOW	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40051	1	ZIO40051-1	FILTER 4 FTW TO FTW HEADER VALVE OPEN	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40051	1	ZIC40051-1	FILTER 4 FTW TO FTW HEADER VALVE CLOSED	35-PI-19		35-PLC-9004	DI	120VAC					
	35	40051	1	ZI40051-1	FILTER 4 FTW TO FTW HEADER VALVE POSITION	35-PI-19		35-PLC-9004	AI	4 - 20 mA					
	35	40051	1	ZC40051-1	FILTER 4 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-19		35-PLC-9004	AO	4 - 20 mA					
	35	40051	1	YA40051-1	FILTER 4 FTW TO FTW HEADER VALVE FAULT	35-PI-19		35-PLC-9004	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	50131	1	AI50131-1	FILTER 5 FILTERED WATER TURBIDITY	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50141	1	AI50141-1	FILTER 5 FILTERED WATER PARTICLE COUNT	35-PI-20		35-PLC-9005	ASCII	RS 485					
	35	50031	3	HS50031-3	FILTER 5 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50031	1	ZC050031-1	FILTER 5 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50031	1	ZCC50031-1	FILTER 5 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50031	1	ZI050031-1	FILTER 5 BACKWASH TO FILTER VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50031	1	ZIC50031-1	FILTER 5 BACKWASH TO FILTER VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50031	1	YA50031-1	FILTER 5 BACKWASH TO FILTER VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50011	3	HS50011-3	FILTER 5 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50011	1	ZC050011-1	FILTER 5 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50011	1	ZCC50011-1	FILTER 5 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50011	1	ZI050011-1	FILTER 5 SW TO UPPER GULLET VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50011	1	ZIC50011-1	FILTER 5 SW TO UPPER GULLET VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50011	1	YA50011-1	FILTER 5 SW TO UPPER GULLET VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50061	3	HS50061-3	FILTER 5 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50061	1	ZC050061-1	FILTER 5 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50061	1	ZCC50061-1	FILTER 5 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-20		35-PLC-9005	DO	120VAC					
	35	50061	1	ZI050061-1	FILTER 5 BA TO LOWER GULLET VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50061	1	ZIC50061-1	FILTER 5 BA TO LOWER GULLET VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50061	1	YA50061-1	FILTER 5 BA TO LOWER GULLET VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50041	3	HS50041-3	FILTER 5 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50041	1	ZI050041-1	FILTER 5 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50041	1	ZIC50041-1	FILTER 5 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50041	1	ZI50041-1	FILTER 5 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50041	1	ZC50041-1	FILTER 5 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-20		35-PLC-9005	AO	4 - 20 mA					
	35	50041	1	YA50041-1	FILTER 5 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50111	1	LI50111-1	FILTER 5 BW TROUGH LEVEL	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50042	1	PI50042-1	FILTER 5 FTW PRESSURE	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50021	3	HS50021-3	FILTER 5 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50021	1	ZI050021-1	FILTER 5 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50021	1	ZIC50021-1	FILTER 5 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50021	1	ZI50021-1	FILTER 5 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50021	1	ZC50021-1	FILTER 5 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-20		35-PLC-9005	AO	4 - 20 mA					
	35	50021	1	YA50021-1	FILTER 5 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50051	3	HS50051-3	FILTER 5 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50050	1	FI50050-1	FILTER 5 FW TO COMBINED FILTER WATER FLOW	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50051	1	ZI050051-1	FILTER 5 FTW TO FTW HEADER VALVE OPEN	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50051	1	ZIC50051-1	FILTER 5 FTW TO FTW HEADER VALVE CLOSED	35-PI-20		35-PLC-9005	DI	120VAC					
	35	50051	1	ZI50051-1	FILTER 5 FTW TO FTW HEADER VALVE POSITION	35-PI-20		35-PLC-9005	AI	4 - 20 mA					
	35	50051	1	ZC50051-1	FILTER 5 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-20		35-PLC-9005	AO	4 - 20 mA					
	35	50051	1	YA50051-1	FILTER 5 FTW TO FTW HEADER VALVE FAULT	35-PI-20		35-PLC-9005	DI	120VAC					

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	35	60131	1	AI60131-1	FILTER 6 FILTERED WATER TURBIDITY	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60141	1	AI60141-1	FILTER 6 FILTERED WATER PARTICLE COUNT	35-PI-21		35-PLC-9006	ASCII	RS 485					
	35	60031	3	HS60031-3	FILTER 6 BACKWASH TO FILTER VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60031	1	ZCO60031-1	FILTER 6 BACKWASH TO FILTER VALVE OPEN COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60031	1	ZCC60031-1	FILTER 6 BACKWASH TO FILTER VALVE CLOSE COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60031	1	ZIO60031-1	FILTER 6 BACKWASH TO FILTER VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60031	1	ZIC60031-1	FILTER 6 BACKWASH TO FILTER VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60031	1	YA60031-1	FILTER 6 BACKWASH TO FILTER VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60011	3	HS60011-3	FILTER 6 SW TO UPPER GULLET VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60011	1	ZCO60011-1	FILTER 6 SW TO UPPER GULLET VALVE OPEN COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60011	1	ZCC60011-1	FILTER 6 SW TO UPPER GULLET VALVE CLOSE COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60011	1	ZIO60011-1	FILTER 6 SW TO UPPER GULLET VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60011	1	ZIC60011-1	FILTER 6 SW TO UPPER GULLET VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60011	1	YA60011-1	FILTER 6 SW TO UPPER GULLET VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60061	3	HS60061-3	FILTER 6 BA TO LOWER GULLET VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60061	1	ZCO60061-1	FILTER 6 BA TO LOWER GULLET VALVE OPEN COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60061	1	ZCC60061-1	FILTER 6 BA TO LOWER GULLET VALVE CLOSE COMMAND	35-PI-21		35-PLC-9006	DO	120VAC					
	35	60061	1	ZIO60061-1	FILTER 6 BA TO LOWER GULLET VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60061	1	ZIC60061-1	FILTER 6 BA TO LOWER GULLET VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60061	1	YA60061-1	FILTER 6 BA TO LOWER GULLET VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60041	3	HS60041-3	FILTER 6 WBW TO WBW EQ BASIN VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60041	1	ZIO60041-1	FILTER 6 WBW TO WBW EQ BASIN VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60041	1	ZIC60041-1	FILTER 6 WBW TO WBW EQ BASIN VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60041	1	ZI60041-1	FILTER 6 WBW TO WBW EQ BASIN VALVE POSITION	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60041	1	ZC60041-1	FILTER 6 WBW TO WBW EQ BASIN VALVE POSITION SETPOINT	35-PI-21		35-PLC-9006	AO	4 - 20 mA					
	35	60041	1	YA60041-1	FILTER 6 WBW TO WBW EQ BASIN VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60111	1	LI60111-1	FILTER 6 BW TROUGH LEVEL	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60042	1	PI60042-1	FILTER 6 FTW PRESSURE	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60021	3	HS60021-3	FILTER 6 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60021	1	ZIO60021-1	FILTER 6 FW TO COMBINED FILTER WATER VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60021	1	ZIC60021-1	FILTER 6 FW TO COMBINED FILTER WATER VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60021	1	ZI60021-1	FILTER 6 FW TO COMBINED FILTER WATER VALVE POSITION	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60021	1	ZC60021-1	FILTER 6 FW TO COMBINED FILTER WATER VALVE POSITION SETPOINT	35-PI-21		35-PLC-9006	AO	4 - 20 mA					
	35	60021	1	YA60021-1	FILTER 6 FW TO COMBINED FILTER WATER VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60051	3	HS60051-3	FILTER 6 FW TO COMBINED FILTER WATER VALVE IN REMOTE	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60060	1	FI60060-1	FILTER 6 FW TO COMBINED FILTER WATER FLOW	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60051	1	ZIO60051-1	FILTER 6 FTW TO FTW HEADER VALVE OPEN	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60051	1	ZIC60051-1	FILTER 6 FTW TO FTW HEADER VALVE CLOSED	35-PI-21		35-PLC-9006	DI	120VAC					
	35	60051	1	ZI60051-1	FILTER 6 FTW TO FTW HEADER VALVE POSITION	35-PI-21		35-PLC-9006	AI	4 - 20 mA					
	35	60051	1	ZC60051-1	FILTER 6 FTW TO FTW HEADER VALVE POSITION SETPOINT	35-PI-21		35-PLC-9006	AO	4 - 20 mA					
	35	60051	1	YA60051-1	FILTER 6 FTW TO FTW HEADER VALVE FAULT	35-PI-21		35-PLC-9006	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	60	00012	1	LI00012-1	WASTE BACKWASH WATER CLARIFIER LEVEL	60-PI-01		ACC2300	AI	4 - 20 mA					
	60	00013	2	HS00013-2	WASTE BACKWASH WATER CLARIFIER IN AUTO	60-PI-01		ACC2300	DI	120VAC					
	60	00013	1	YL00013-1	WASTE BACKWASH WATER CLARIFIER RUNNING	60-PI-01		ACC2300	DI	120VAC					
	60	00013	1	OAH00013-1	WASTE BACKWASH WATER CLARIFIER HIGH TORQUE	60-PI-01		ACC2300	DI	120VAC					
	60	00013	1	YC00013-1	WASTE BACKWASH WATER CLARIFIER START	60-PI-01		ACC2300	DO	120VAC					
	60	00031	3	HS00031-3	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE IN AUTO	60-PI-01		ACC2300	DI	120VAC					
	60	00031	1	YA00031-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE FAULT	60-PI-01		ACC2300	DI	120VAC					
	60	00031	1	ZIC00031-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE CLOSED	60-PI-01		ACC2300	DI	120VAC					
	60	00031	1	ZIO00031-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE OPENED	60-PI-01		ACC2300	DI	120VAC					
	60	00031	1	ZCC00031-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE OPEN COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00031	1	ZCO00031-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE CLOSE COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00030	3	HS00030-3	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE IN AUTO	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	YA00030-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE FAULT	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZIC00030-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE CLOSED	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZIO00030-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE OPENED	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZCC00030-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE OPEN COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00030	1	ZCO00030-1	WASTE BACKWASH WATER CLARIFIER RECYCLE VALVE CLOSE COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00030	3	HS00032-3	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE IN AUTO	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	YA00032-1	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE FAULT	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZIC00032-1	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE CLOSED	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZIO00032-1	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE OPENED	60-PI-01		ACC2300	DI	120VAC					
	60	00030	1	ZCC00032-1	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE OPEN COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00030	1	ZCO00032-1	WASTE BACKWASH WATER CLARIFIER SOLIDS VALVE CLOSE COMMAND	60-PI-01		ACC2300	DO	120VAC					
	60	00014	1	LAH00014-1	RECYCLED WATER PUMP STATION HIGH LEVEL	60-PI-02		ACC2300	DI	120VAC					
	60	00014	1	LAM00014-1	RECYCLED WATER PUMP STATION MID LEVEL	60-PI-02		ACC2300	DI	120VAC					
	60	00014	1	LAL00014-1	RECYCLED WATER PUMP STATION LOW LEVEL	60-PI-02		ACC2300	DI	120VAC					
	60	00010	4	HS00010-4	RECYCLE PUMP 1 IN AUTO	60-PI-02		ACC2300	DI	120VAC					
	60	00020	1	HS00020-1	RECYCLE PUMP 2 IN AUTO	60-PI-02		ACC2300	DI	120VAC					
	60	00014	2	LAH00014-2	RECYCLE WATER PUMP STATION HIGH LEVEL	60-PI-02		ACC2300	DI	120VAC					
	60	00010	1	YL00010-1	RECYCLE PUMP 1 RUNNING	60-PI-02		ACC2300	DI	120VAC					
	60	00010	1	YA00010-1	RECYCLE PUMP 1 FAULT	60-PI-02		ACC2300	DI	120VAC					
	60	00020	1	YL00020-1	RECYCLE PUMP 2 RUNNING	60-PI-02		ACC2300	DI	120VAC					
	60	00020	1	YA00020-1	RECYCLE PUMP 2 FAULT	60-PI-02		ACC2300	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	70	00011	1	TIT00011-1	AIR SCOUR BLOWER 1 INTAKE AIR TEMPERATURE	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00021	1	TIT00021-1	AIR SCOUR BLOWER 2 INTAKE AIR TEMPERATURE	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00013	3	HS00013-3	AIR SCOUR BLOWER 1 INTAKE AIR VALVE IN REMOTE	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00013	1	YA00013-1	AIR SCOUR BLOWER 1 INTAKE AIR VALVE FAIL	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00013	1	ZL000013-1	AIR SCOUR BLOWER 1 INTAKE AIR VALVE OPEN	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00013	1	ZLC00013-1	AIR SCOUR BLOWER 1 INTAKE AIR VALVE CLOSED	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00013	1	ZC00013-1	AIR SCOUR BLOWER 1 INTAKE AIR VALVE POSITION SETPOINT	35-PI-24		70-PLC-9000	AO	4 - 20 mA					
	70	00013	1	ZI00013-1	AIR SCOUR BLOWER 1 INTAKE AIR VALVE POSITION	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00012	1	PDAH00012-1	AIR SCOUR BLOWER 1 INTAKE AIR HIGH DIFFERENTIAL PRESSURE	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00022	1	PDAH00022-1	AIR SCOUR BLOWER 2 INTAKE AIR HIGH DIFFERENTIAL PRESSURE	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00010	3	HS00010-3	AIR SCOUR BLOWER 1 IN AUTO	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00010	2	YL00010-2	AIR SCOUR BLOWER 1 RUNNING	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00010	2	YA00010-2	AIR SCOUR BLOWER 1 FAULT	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00010	1	YC00010-1	AIR SCOUR BLOWER 1 START	35-PI-24		70-PLC-9000	DO	120VAC					
	70	00023	3	HS00023-3	AIR SCOUR BLOWER 2 INTAKE AIR VALVE IN REMOTE	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00023	1	YA00023-1	AIR SCOUR BLOWER 2 INTAKE AIR VALVE FAIL	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00023	1	ZL000023-1	AIR SCOUR BLOWER 2 INTAKE AIR VALVE OPEN	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00023	1	ZLC00023-1	AIR SCOUR BLOWER 2 INTAKE AIR VALVE CLOSED	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00023	1	ZC00023-1	AIR SCOUR BLOWER 2 INTAKE AIR VALVE POSITION SETPOINT	35-PI-24		70-PLC-9000	AO	4 - 20 mA					
	70	00023	1	ZI00023-1	AIR SCOUR BLOWER 2 INTAKE AIR VALVE POSITION	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00020	3	HS00020-3	AIR SCOUR BLOWER 2 IN AUTO	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00020	2	YL00020-2	AIR SCOUR BLOWER 2 RUNNING	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00020	2	YA00020-2	AIR SCOUR BLOWER 2 FAULT	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00020	1	YC00020-1	AIR SCOUR BLOWER 2 START	35-PI-24		70-PLC-9000	DO	120VAC					
	70	00017	3	HS00017-3	AIR SCOUR VENT VALVE IN AUTO	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00017	1	ZI000017-1	AIR SCOUR VENT VALVE OPENED	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00017	1	ZLC00017-1	AIR SCOUR VENT VALVE CLOSED	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00017	1	YA00017-1	AIR SCOUR VENT VALVE FAULT	35-PI-24		70-PLC-9000	DI	120VAC					
	70	00017	1	ZC000017-1	AIR SCOUR VENT VALVE OPEN COMMAND	35-PI-24		70-PLC-9000	DO	120VAC					
	70	00017	1	ZCC00017-1	AIR SCOUR VENT VALVE CLOSE COMMAND	35-PI-24		70-PLC-9000	DO	120VAC					
	70	00014	1	TI00014-1	AIR SCOUR HEADER TEMPERATURE	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00015	1	PI00015-1	AIR SCOUR HEADER PRESSURE	35-PI-24		70-PLC-9000	AI	4 - 20 mA					
	70	00016	1	ZCC00016-1	AIR SCOUR LINE TO TRENCH DRAIN VALVE CLOSE COMMAND	35-PI-24		70-PLC-9000	DO	120VAC					
	70	10010	3	HS10010-3	CLEARWELL 1 INLET GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10010	1	ZC010010-1	CLEARWELL 1 INLET GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	10010	1	ZCC10010-1	CLEARWELL 1 INLET GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	10010	1	ZI010010-1	CLEARWELL 1 INLET GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10010	1	ZIC10010-1	CLEARWELL 1 INLET GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10010	1	YA10010-1	CLEARWELL 1 INLET GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20010	3	HS20010-3	CLEARWELL 2 INLET GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20010	1	ZC020010-1	CLEARWELL 2 INLET GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	20010	1	ZCC20010-1	CLEARWELL 2 INLET GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	20010	1	ZI020010-1	CLEARWELL 2 INLET GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20010	1	ZIC20010-1	CLEARWELL 2 INLET GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20010	1	YA20010-1	CLEARWELL 2 INLET GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10020	3	HS10020-3	CLEARWELL 1 TO TROUGH GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10020	1	ZC010020-1	CLEARWELL 1 TO TROUGH GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	10020	1	ZCC10020-1	CLEARWELL 1 TO TROUGH GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	10020	1	ZI010020-1	CLEARWELL 1 TO TROUGH GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10020	1	ZIC10020-1	CLEARWELL 1 TO TROUGH GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC					
	70	10020	1	YA10020-1	CLEARWELL 1 TO TROUGH GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20020	3	HS20020-3	CLEARWELL 2 TO TROUGH GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20020	1	ZC020020-1	CLEARWELL 2 TO TROUGH GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	20020	1	ZCC20020-1	CLEARWELL 2 TO TROUGH GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					
	70	20020	1	ZI020020-1	CLEARWELL 2 TO TROUGH GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20020	1	ZIC20020-1	CLEARWELL 2 TO TROUGH GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC					
	70	20020	1	YA20020-1	CLEARWELL 2 TO TROUGH GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC					
	70	00099	3	HS00099-3	CLEARWELL DRAIN PUMP 1 GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC					
	70	00099	1	ZC000099-1	CLEARWELL DRAIN PUMP 1 GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC					

	70	00099	1	ZCC00099-1	CLEARWELL DRAIN PUMP 1 GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC				
	70	00099	1	ZIO00099-1	CLEARWELL DRAIN PUMP 1 GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00099	1	ZIC00099-1	CLEARWELL DRAIN PUMP 1 GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00099	1	YA00099-1	CLEARWELL DRAIN PUMP 1 GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00100	3	HS00100-3	CLEARWELL DRAIN PUMP 2 GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00100	1	ZCO00100-1	CLEARWELL DRAIN PUMP 2 GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC				
	70	00100	1	ZCC00100-1	CLEARWELL DRAIN PUMP 2 GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC				
	70	00100	1	ZIO00100-1	CLEARWELL DRAIN PUMP 2 GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00100	1	ZIC00100-1	CLEARWELL DRAIN PUMP 2 GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00100	1	YA00100-1	CLEARWELL DRAIN PUMP 2 GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	3	HS00010-3	BACKWAS PUMP STATION GATE IN REMOTE	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	1	ZCO00010-1	BACKWAS PUMP STATION GATE OPEN COMMAND	70-PI-01		70-PLC-9000	DO	120VAC				
	70	00010	1	ZCC00010-1	BACKWAS PUMP STATION GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	DO	120VAC				
	70	00010	1	ZIO00010-1	BACKWAS PUMP STATION GATE OPEN	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	1	ZIC00010-1	BACKWAS PUMP STATION GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	1	YA00010-1	BACKWAS PUMP STATION GATE FAULT	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	1	FI00010-1	CLEARWELL DRAIN PUMP 1 GATE FLOW	70-PI-01		70-PLC-9000	AI	4 - 20 mA				
	70	00020	1	FI00020-1	CLEARWELL DRAIN PUMP 2 GATE FLOW	70-PI-01		70-PLC-9000	AI	4 - 20 mA				
	70	10010	1	LI10010-1	CLEARWELL DRAIN PUMP 2 GATE CLOSE COMMAND	70-PI-01		70-PLC-9000	AI	4 - 20 mA				
	70	20010	1	LI20010-1	CLEARWELL DRAIN PUMP 2 GATE OPEN	70-PI-01		70-PLC-9000	AI	4 - 20 mA				
	70	00060	1	LALL00060-1	CLEARWELL DRAIN PUMP 2 GATE CLOSED	70-PI-01		70-PLC-9000	DI	120VAC				
	70	00010	3	HS00010-3	TREATED WATER SAMPLE PUMP IN REMOTE	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00010	2	YL00010-2	TREATED WATER SAMPLE PUMP RUNNING	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00010	2	YA00010-2	TREATED WATER SAMPLE PUMP FAULT	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00010	1	YC00010-1	TREATED WATER SAMPLE PUMP START	70-PI-02		70-PLC-9000	DO	120VAC				
	70	00060	3	HS00060-3	CARRIER WATER PUMP 1 IN REMOTE	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00060	2	YL00060-2	CARRIER WATER PUMP 1 RUNNING	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00060	2	YA00060-2	CARRIER WATER PUMP 1 FAULT	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00060	1	YC00060-1	CARRIER WATER PUMP 1 START	70-PI-02		70-PLC-9000	DO	120VAC				
	70	00070	3	HS00070-3	CARRIER WATER PUMP 2 IN REMOTE	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00070	2	YL00070-2	CARRIER WATER PUMP 2 RUNNING	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00070	2	YA00070-2	CARRIER WATER PUMP 2 FAULT	70-PI-02		70-PLC-9000	DI	120VAC				
	70	00070	1	YC00070-1	CARRIER WATER PUMP 2 START	70-PI-02		70-PLC-9000	DO	120VAC				
	70	00072	1	PI00072-1	CARRIER WATER PRESSURE	70-PI-02		70-PLC-9000	AI	4 - 20 mA				
	70	00012	1	PI00012-1	TREATED WATER SAMPLE PRESSURE	70-PI-02		70-PLC-9000	AI	4 - 20 mA				
	70	00013	1	AI00013-1	TREATED WATER SAMPLE pH	70-PI-02		70-PLC-9000	AI	4 - 20 mA				
	70	00014	1	AI00014-1	TREATED WATER SAMPLE CHLORINE	70-PI-02		70-PLC-9000	AI	4 - 20 mA				
	70	00015	1	AI00015-1	TREATED WATER SAMPLE FLUORIDE	70-PI-02		70-PLC-9000	AI	4 - 20 mA				
	73	00014	1	LI00014-1	CLEARWELL PW PUMP STATION LEVEL	70-PI-03		70-PLC-9000	AI	4 - 20 mA				
	73	00015	1	LALL00015-1	CLEARWELL PW PUMP STATION LOW-LOW LEVEL	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00010	3	HS00010-3	PLANT WATER PUMP 1 IN REMOTE	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00010	2	YL00010-2	PLANT WATER PUMP 1 RUNNING	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00010	2	YA00010-2	PLANT WATER PUMP 1 FAULT	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00010	2	SI00010-2	PLANT WATER PUMP 1 SPEED	70-PI-03		70-PLC-9000	AI	4 - 20 mA				
	73	00010	2	SC00010-2	PLANT WATER PUMP 1 SPEED SETPOINT	70-PI-03		70-PLC-9000	AO	4 - 20 mA				
	73	00010	1	YC00010-1	PLANT WATER PUMP 1 START	70-PI-03		70-PLC-9000	DO	120VAC				
	73	00012	1	FAL00012-1	PLANT WATER PUMP 1 LOW FLOW	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00013	3	HS00013-3	PLANT WATER PUMP 1 VALVE IN REMOTE	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00013	1	ZCO00013-1	PLANT WATER PUMP 1 VALVE OPEN COMMAND	70-PI-03		70-PLC-9000	DO	120VAC				
	73	00013	1	ZCC00013-1	PLANT WATER PUMP 1 VALVE CLOSE COMMAND	70-PI-03		70-PLC-9000	DO	120VAC				
	73	00013	1	ZIO00013-1	PLANT WATER PUMP 1 VALVE OPEN	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00013	1	ZIC00013-1	PLANT WATER PUMP 1 VALVE CLOSED	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00013	1	YA00013-1	PLANT WATER PUMP 1 VALVE FAULT	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00020	3	HS00020-3	PLANT WATER PUMP 2 IN REMOTE	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00020	2	YL00020-2	PLANT WATER PUMP 2 RUNNING	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00020	2	YA00020-2	PLANT WATER PUMP 2 FAULT	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00020	2	SI00020-2	PLANT WATER PUMP 2 SPEED	70-PI-03		70-PLC-9000	AI	4 - 20 mA				
	73	00020	2	SC00020-2	PLANT WATER PUMP 2 SPEED SETPOINT	70-PI-03		70-PLC-9000	AO	4 - 20 mA				
	73	00020	1	YC00020-1	PLANT WATER PUMP 2 START	70-PI-03		70-PLC-9000	DO	120VAC				
	73	00022	1	FAL00022-1	PLANT WATER PUMP 2 LOW FLOW	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00023	3	HS00023-3	PLANT WATER PUMP 2 VALVE IN REMOTE	70-PI-03		70-PLC-9000	DI	120VAC				
	73	00023	1	ZCO00023-1	PLANT WATER PUMP 2 VALVE OPEN COMMAND	70-PI-03		70-PLC-9000	DO	120VAC				

	73	00023	1	ZCC00023-1	PLANT WATER PUMP 2 VALVE CLOSE COMMAND	70-PI-03		70-PLC-9000	DO	120VAC					
	73	00023	1	ZIO00023-1	PLANT WATER PUMP 2 VALVE OPEN	70-PI-03		70-PLC-9000	DI	120VAC					
	73	00023	1	ZIC00023-1	PLANT WATER PUMP 2 VALVE CLOSED	70-PI-03		70-PLC-9000	DI	120VAC					
	73	00023	1	YA00023-1	PLANT WATER PUMP 2 VALVE FAULT	70-PI-03		70-PLC-9000	DI	120VAC					
	71	00017	3	HS00017-3	BACKWASH TANK VALVE IN AUTO	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00017	1	ZIO00017-1	BACKWASH TANK VALVE OPENED	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00017	1	ZIC00017-1	BACKWASH TANK VALVE CLOSED	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00017	1	YA00017-1	BACKWASH TANK VALVE FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00017	1	ZCO00017-1	BACKWASH TANK VALVE OPEN COMMAND	70-PI-04		70-PLC-9000	DO	120VAC					
	71	00017	1	ZCC00017-1	BACKWASH TANK VALVE CLOSE COMMAND	70-PI-04		70-PLC-9000	DO	120VAC					
	71	00010	3	HS00010-3	BACKWASH SUPPLY PUMP 1 IN AUTO	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00010	2	YL00010-2	BACKWASH SUPPLY PUMP 1 RUNNING	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00010	2	YA00010-2	BACKWASH SUPPLY PUMP 1 FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00010	1	YC00010-1	BACKWASH SUPPLY PUMP 1 START	70-PI-04		70-PLC-9000	DO	120VAC					
	71	00010	1	SC00010-1	BACKWASH SUPPLY PUMP 1 SPEED SETPT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00010	1	SI00010-1	BACKWASH SUPPLY PUMP 1 SPEED	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00012	1	FAL00012-1	BACKWASH SUPPLY PUMP 1 LOW FLOW	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00013	3	HS00013-3	BACKWASH SUPPLY PUMP 1 VALVE IN REMOTE	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00013	1	ZIO00013-1	BACKWASH SUPPLY PUMP 1 VALVE OPEN	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00013	1	ZIC00013-1	BACKWASH SUPPLY PUMP 1 VALVE CLOSED	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00013	1	ZIO0013-1	BACKWASH SUPPLY PUMP 1 VALVE POSITION	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00013	1	ZCO0013-1	BACKWASH SUPPLY PUMP 1 VALVE POSITION SETPOINT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00013	1	YA00013-1	BACKWASH SUPPLY PUMP 1 VALVE FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00020	3	HS00020-3	BACKWASH SUPPLY PUMP 2 IN AUTO	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00020	2	YL00020-2	BACKWASH SUPPLY PUMP 2 RUNNING	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00020	2	YA00020-2	BACKWASH SUPPLY PUMP 2 FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00020	1	YC00020-1	BACKWASH SUPPLY PUMP 2 START	70-PI-04		70-PLC-9000	DO	120VAC					
	71	00020	1	SC00020-1	BACKWASH SUPPLY PUMP 2 SPEED SETPT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00020	1	SI00020-1	BACKWASH SUPPLY PUMP 2 SPEED	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00022	1	FAL00022-1	BACKWASH SUPPLY PUMP 2 LOW FLOW	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00023	3	HS00023-3	BACKWASH SUPPLY PUMP 2 VALVE IN REMOTE	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00023	1	ZIO00023-1	BACKWASH SUPPLY PUMP 2 VALVE OPEN	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00023	1	ZIC00023-1	BACKWASH SUPPLY PUMP 2 VALVE CLOSED	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00023	1	ZIO0023-1	BACKWASH SUPPLY PUMP 2 VALVE POSITION	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00023	1	ZCO0023-1	BACKWASH SUPPLY PUMP 2 VALVE POSITION SETPOINT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00023	1	YA00023-1	BACKWASH SUPPLY PUMP 2 VALVE FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00030	3	HS00030-3	BACKWASH SUPPLY PUMP 3 IN AUTO	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00030	2	YL00030-2	BACKWASH SUPPLY PUMP 3 RUNNING	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00030	2	YA00030-2	BACKWASH SUPPLY PUMP 3 FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00030	1	YC00030-1	BACKWASH SUPPLY PUMP 3 START	70-PI-04		70-PLC-9000	DO	120VAC					
	71	00030	1	SC00030-1	BACKWASH SUPPLY PUMP 3 SPEED SETPT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00030	1	SI00030-1	BACKWASH SUPPLY PUMP 3 SPEED	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00032	1	FAL00032-1	BACKWASH SUPPLY PUMP 3 LOW FLOW	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00033	3	HS00033-3	BACKWASH SUPPLY PUMP 3 VALVE IN REMOTE	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00033	1	ZIO00033-1	BACKWASH SUPPLY PUMP 3 VALVE OPEN	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00033	1	ZIC00033-1	BACKWASH SUPPLY PUMP 3 VALVE CLOSED	70-PI-04		70-PLC-9000	DI	120VAC					
	71	00033	1	ZIO0023-1	BACKWASH SUPPLY PUMP 3 VALVE POSITION	70-PI-04		70-PLC-9000	AI	4 - 20 mA					
	71	00033	1	ZCO0023-1	BACKWASH SUPPLY PUMP 3 VALVE POSITION SETPOINT	70-PI-04		70-PLC-9000	AO	4 - 20 mA					
	71	00033	1	YA00033-1	BACKWASH SUPPLY PUMP 3 VALVE FAULT	70-PI-04		70-PLC-9000	DI	120VAC					
	70	00016	1	LIO0016-1	CLEARWELL BACKWASH CONSTANT HEAD LEVEL	70-PI-05		70-PLC-9000	AI	4 - 20 mA					
	70	00017	1	LAH00017-1	UNDERDRAIN PUMP STATION HIGH LEVEL	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00017	1	LAM00017-1	UNDERDRAIN PUMP STATION MID LEVEL	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00017	1	LAL00017-1	UNDERDRAIN PUMP STATION LOW LEVEL	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00020	3	HS00020-3	UNDERDRAIN PUMP STATION PUMP 1 IN AUTO	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00020	2	YL00020-2	UNDERDRAIN PUMP STATION PUMP 1 RUNNING	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00020	2	YA00020-2	UNDERDRAIN PUMP STATION PUMP 1 FAULT	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00020	1	YC00020-1	UNDERDRAIN PUMP STATION PUMP 1 START	70-PI-06		70-PLC-9000	DO	120VAC					
	70	00020	1	MAH00020-1	UNDERDRAIN PUMP STATION PUMP 1 MOISTURE	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00020	1	TAH00020-1	UNDERDRAIN PUMP STATION PUMP 1 MOTOR WINDING TEMP	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00030	3	HS00030-3	UNDERDRAIN PUMP STATION PUMP 2 IN AUTO	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00030	2	YL00030-2	UNDERDRAIN PUMP STATION PUMP 2 RUNNING	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00030	2	YA00030-2	UNDERDRAIN PUMP STATION PUMP 2 FAULT	70-PI-06		70-PLC-9000	DI	120VAC					

	70	00030	1	YC00030-1	UNDERDRAIN PUMP STATION PUMP 2 START	70-PI-06		70-PLC-9000	DO	120VAC					
	70	00030	1	MAH00030-1	UNDERDRAIN PUMP STATION PUMP 2 MOISTURE	70-PI-06		70-PLC-9000	DI	120VAC					
	70	00030	1	TAH00030-1	UNDERDRAIN PUMP STATION PUMP 2 MOTOR WINDING TEMP	70-PI-06		70-PLC-9000	DI	120VAC					

Process Control System Input/Output List

Item	Area	Loop Number	Loop Number Suffix	Tag	Description	P&ID	CONTROLSPEC	PLC/RIO	I/O Type	Module/Device Type	Rack	Slot	Point	I/O Wiring Detail/Diagram	Application Notes
	87	00060	3	HS00060-3	FLUORIDE CARRIER WATER VALVE IN REMOTE	87-PI-01		87-PLC-9000	DI	120VAC					
	87	00060	1	ZIO00060-1	FLUORIDE CARRIER WATER VALVE OPENED	87-PI-01		87-PLC-9000	DI	120VAC					
	87	00060	1	ZIC00060-1	FLUORIDE CARRIER WATER VALVE CLOSED	87-PI-01		87-PLC-9000	DI	120VAC					
	87	00060	1	YA00060-1	FLUORIDE CARRIER WATER VALVE FAULT	87-PI-01		87-PLC-9000	DI	120VAC					
	87	00060	1	ZC00060-1	FLUORIDE CARRIER WATER VALVE POSITION SETPT	87-PI-01		87-PLC-9000	AO	4 - 20 mA					
	87	00060	1	ZI00060-1	FLUORIDE CARRIER WATER VALVE POSITION	87-PI-01		87-PLC-9000	AI	4 - 20 mA					
	87	00061	1	FAL00061-1	FLUORIDE CARRIER WATER LOW FLOW	87-PI-01		87-PLC-9000	DI	120VAC					
	87	00012	1	FAH00012-1	FLUORIDE BUILDING INSIDE EYEWASH ACTIVATED	87-PI-01		87-PLC-9000	DI	120VAC					EXISTING
	87	00013	1	FAH00013-1	FLUORIDE BUILDING OUTSIDE EYEWASH ACTIVATED	87-PI-01		87-PLC-9000	DI	120VAC					

SECTION 40 61 96

PROCESS CONTROL DESCRIPTIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies control by the Programmable Logic Controller (PLC) based Supervisory Control and Data Acquisition (SCADA) system for the City Creek Water Treatment Plant.

B. [Control strategies for packaged equipment are specified in the respective equipment specifications.]

C. These control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, testing, and commissioning. They describe how the system is to operate, and do not necessarily include every component required to make the system function.

D. Control strategies describe sequential and interlocking control functions, analog control functions, color-graphic video display SCADA Computers and Operator Interfaces and alarm and event logging. All control functions shall be programmed in the control system PLC controller, the Operator Interfaces and SCADA computers shall perform supervisory functions only.

E. The Contractor shall provide the labor and equipment to test the specified control strategies per Section 40 61 21.

F. Programming: Refer to Section 40 61 13.

PART 2 NOT USED

PART 3 EXECUTION

3.01 STANDARD INTERLOCKS

A. Interlocks:
   1. Standard Interlocks (I) shut down and prevent equipment from operating. These are defined here and referenced in Control Strategies below.
   2. Hardwired interlocks are effective whether the PLC system is in operation or not. These are specified in the respective equipment specifications.
   3. Software interlocks are provided by the PLC and are usually only effective when the equipment is operating in Remote mode unless noted. For this reason, software interlocks are not always in effect for equipment or personnel protection.

I1 – MOTOR PROTECTION

Equipment motor protection includes motor starter overload and/or Variable Frequency Drive (VFD) or Reduced Voltage Solid State Starter (RVSS) fault, hardwired only. Manual reset required at the starter, VFD, or RVSS.

I2 – HIGH DISCHARGE PRESSURE

Equipment protection from pressure switch, hardwired only. Time delayed; no time delay for positive displacement pumps. Manual reset required at the starter, VFD, or RVSS. (Note: For protection from a discharge pressure transmitter instead, refer to Control Strategy 7 High Alarm below, software interlock.)

I3 – HIGH MOTOR TEMPERATURE

Equipment motor protection from temperature switch or temperature sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for large (perhaps over 100 hp) or VFD driven motors and submersible pumps.)

I4 – HIGH MOTOR BEARING TEMPERATURE

Equipment protection from temperature switch or temperature sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for large (perhaps over 100 hp) motors or per Owner or Vendor recommendations.)

I5 – HIGH PUMP/FAN BEARING TEMPERATURE

Equipment protection from temperature switch or temperature sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for large pump/fan or per Owner or Vendor recommendations.)

I6 – HIGH PUMP/FAN VIBRATION

Equipment protection from vibration switch or vibration sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for large pump/fan or per Owner or Vendor recommendations.)

I7 – HIGH PUMP STATOR TEMPERATURE

Equipment protection from temperature switch or temperature sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for progressive cavity pumps as an indication of loss of suction product.)

I8 – LOW SPEED

Equipment protection from speed switch or speed sensors and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for conveyors.)

I9 – EMERGENCY STOP

Personnel command from maintained pushbutton or pull-cord, hardwired only. Manual reset required at the pushbutton or pull-cord. (Note: Typical for equipment, required for conveyors.)

I10 – HIGH MOISTURE

Equipment motor protection from moisture sensor and switching relay, hardwired only. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for submersible sewage pumps.)

I11 – LOW FLUSH WATER FLOW

Equipment protection from flow switch, hardwired only. Time delayed. Manual reset required at the starter, VFD, or RVSS. (Note: Typical for pumps with mechanical seals, refer to process mechanical. May require a pre-flushing sequence.)

I13 – DIAPHRAGM LEAK

Equipment protection from conductivity sensor and switching relay, hardwired only. Manual reset required at the starter or VFD.

I14 – OVERTORQUE

Equipment protection from torque switch, hardwired only. Manual reset required at the starter or VFD.

I15 – LOW MOTOR CURRENT

Equipment protection from motor current switch, hardwired only. Time delayed. Manual reset required at the starter, VFD, or RVSS.

I16 – LOW OIL PRESSURE

Equipment protection from pressure switch, hardwired only. Time delayed. Manual reset required at the starter, VFD, or RVSS.

I17 – LOW OIL LEVEL

Equipment protection from level switch, hardwired only. Time delayed. Manual reset required at the starter, VFD, or RVSS.

I18 – LOW SUCTION TANK LEVEL

Equipment protection from level switch, hardwired only. Self-resetting.

I19 – LOW SUCTION PRESSURE

Equipment protection from pressure switch, hardwired only. Time delayed; no time delay for positive displacement pumps. Self-resetting.

I30 – TRANSFER SWITCH TRANSFERRING POSITION AND DELAYED EQUIPMENT RESTARTING

Nuisance circuit breaker trip protection from automatic transfer switch or controls via the PLC, software only. Grouped equipment is prevented from being called to start in REMOTE mode when the transfer switch or means is transferring between the utility and standby positions (either direction), and for a time delay thereafter as defined below.

I31 – TRANSFER SWITCH TRANSFERRING POSITION – GROUP 1

Refer to Interlock I30 above, 5 second delay.

I32 – TRANSFER SWITCH TRANSFERRING POSITION – GROUP 2

Refer to Interlock I30 above, 10 second delay.

I33 – TRANSFER SWITCH TRANSFERRING POSITION – GROUP 3

Refer to Interlock I30 above, 15 second delay.

I34 – TRANSFER SWITCH TRANSFERRING POSITION – GROUP 4

Refer to Interlock I30 above, 20 second delay.

3.02 STANDARD CONTROL STRATEGIES

A. Control Strategies:

1. Standard Control Strategies (CS) define common equipment operations performed by the PLC software.
2. Hardwired control strategies are effective whether the PLC system is in operation or not. These are specified in the respective equipment specifications.
3. Control strategies unique to each process system are defined starting in paragraph 3.03 below.
4. Standard Control Strategies denoted with an asterisk (*) shall be provided as applicable, unless noted otherwise.
5.

CS1 - EQUIPMENT RUN TIME TOTALIZATION*

Equipment run time totalization will be calculated and maintained by the PLC based on equipment run status. Totalize in hours from 0 to 9999. Provide unless physical run time hour meters are specified.

SCADA: Display total in hours.

CS2 - FLOW TOTALIZATION*

Flow totalization will be calculated and maintained by the PLC whenever flow signals exceeds 2-1/2 % of full-scale value and analog signal has not failed (refer to CS10). Totalize in gallons times 1,000 (kGal) or gallons times 1,000,000 (MGal) as shown on the P&ID. Totalize from 0 to 9999.

SCADA: Display total in kGal or MGal as shown on P&ID.

CS3 - PROCESS ALARM(S), SELF-RESETTING*

Process alarms as shown on the P&ID will be determined and maintained by the PLC:

1. Low-Low Alarm: Point value is equal to or less than a predetermined alarm value.
2. Low Alarm: Point value is equal to or less than a predetermined alarm value.
3. High Alarm: Point value is equal to or greater than a predetermined alarm value.
4. High-High Alarm: Point value is equal to or greater than a predetermined alarm value.

An analog point which is in alarm status will not be changed to normal status until the point value changes by the predetermined deadband value for the point, initial setting of 5% of full-scale range. Alarm setpoints are provided in paragraph 40 06 70 instrument index.

SCADA: Display alarms. Display active and cleared-but-unacknowledged alarms in the alarm summary.

CS7 - PROCESS ALARM(S), MANUAL RESET REQUIRED

Process alarms as shown on the P&ID will be determined and maintained by the PLC:

1. Low-Low Alarm: Point value is equal to or less than a predetermined alarm value. This is typically an equipment shutdown alarm.
2. Low Alarm: Point value is equal to or less than a predetermined alarm value.
3. High Alarm: Point value is equal to or greater than a predetermined alarm value.
4. High-High Alarm: Point value is equal to or greater than a predetermined alarm value. This is typically an equipment shutdown alarm.

An analog point which is in alarm status will not be changed to normal status until reset by the SCADA Operator and the point value changes by the predetermined deadband value for the point, initial setting of 5% of full-scale range. PLC alarm setpoints are provided in paragraph 40 06 70-3.03.

SCADA: Display alarms. Display active and cleared-but-unacknowledged alarms in the alarm summary. SCADA allows Operator reset of alarms.

CS9 - DISCRETE LOGICAL POINT STATUS*

The status of each discrete logical point will also be maintained in the PLC. Discrete logical points are points which depend upon the status of one or several discrete input points. For example, equipment failed logical status will result from a loss of ready status when running. Loss of ready status when NOT running will not result in a failed logical status.

SCADA: Display the status of all discrete and logical discrete status points.

CS10 - ANALOG POINT STATUS*

Analog input points will be checked by the PLC for the following status conditions:

1. Failed: Point value is less than or greater than the specified value range typically, less than 3.6 milliamps (mA) and greater than 21.6 mA.

SCADA: Display alarm. Display active and cleared-but-unacknowledged alarm in the alarm summary

CS11 - EQUIPMENT FAILURE*

The failure of PLC controlled equipment (pumps, blowers, compressors, fans, etc.) will be monitored by the PLC system. Equipment will be considered failed under the following conditions:

1. The equipment is in REMOTE and the PLC system attempts to operate the equipment and it does not respond within a defined time period, typically for 30 seconds.
2. The equipment is in REMOTE and running and for whatever reason other than the PLC system requesting the equipment to "STOP," the equipment stops.

CS12 – PLC INPUTS AND OUTPUTS STATUS*

The PLC will monitor status of each individual input, output, communication module, and all processor statuses available.

SCADA: Display racks with status for each module, using descriptive terms for alarms. Display processor battery status. Display alarms. Display active and cleared-but-unacknowledged alarm in the alarm summary

CS13 - GENERAL RECORDING SYSTEM*

The Remote SCADA workstation will store historical input point data and generate reports based upon process variables (pressure, flow, temperature, level and analytical) and equipment status (speed, and motor current or run/off status) in real-time and from recent historical data. The exact report requirements will be determined by the OWNER and will be configured by others during the project construction period.

CS15 - GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM

All analog control functions will be provided as required and will include but not be limited to the following:

1. Proportional-Integral-Derivative (PID) Control--Standard controller functions with balanceless, bumpless transfer from manual to automatic, manual overrides, external reset and output summing capabilities. Provision for cascade, rationing gain, bias, lead-lag, dead-time, feed forward and feedback control will be available.
2. SCADA display system will have a common PID controller operator interface for all equipment utilizing PID control. Controller operator interface will include alphanumeric and graphic indication of the following features as a minimum:
    a. ID of controlled equipment.
    b. ID of process variable input.
    c. Controller setpoint value.
    d. Process variable value.
    e. Controller output value.
    f. Setpoint adjustment interface.
    g. Indication if setpoint is under LOCAL or REMOTE control.
    h. Local/Manual control output adjustment interface.
    i. Indication if control output is under local/manual control or under control of process controller.
3. Computational Functions--On-line mathematical functions will be available to provide real-time computational capability of control variables for use in feed-forward and other advanced control functions.
4. Appropriate control action(s) will be provided as needed.

CS16 - TREND PLOTS*

SCADA workstations will graphically plot trends of process variables (pressure, flow, temperature, level and analytical), controller setpoints, and equipment status (motor current) in real-time and from historical data. The plant operator will be able to select the plotting interval, within the limits of the actual data collection. Four trends per display view will be possible.

In addition to the plotted data, a trend will include:

1. Time.
2. Date.
3. Tag number.
4. Plotting interval.
5. Time at start.
6. Time at latest value.

CS17 – COLOR NOTATION FOR DYNAMIC OBJECTS ON CONTROL GRAPHIC DISPLAY SCREENS*

All dynamic objects on control graphic display screens will be provided with multiple-color display to identify status as tabulated below:

Equipment	Status	Required color
Motor	Running	Red
Motor	Ready or Off	Green
Valve/Gate	Opened position	Red
Valve/Gate	Closed position	Green
All	Power on	White
All	Abnormal condition	Amber (Yellow)
All	Advisory, Control Mode	Blue

CS18 - DIGITAL ALARM SYSTEM*

Alarms as shown on the P&ID will be determined and maintained by the PLC, whether specific control strategies are provided. Digital inputs can be from field instruments (level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units).

SCADA: Display alarms. Display active and cleared-but-unacknowledged alarms in the alarm summary.

CS20 - DIGITAL STATUS SYSTEM*

Digital input status will be displayed on SCADA screens as required by the reference drawings and specifications regardless whether specific control strategies are provided. Each digital input will be shown in its appropriate process screen and/or equipment status screen.

Digital inputs can be originated from field instruments (motorized actuators, HVAC related air handling units, power management related contact inputs, level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units).

CS24 - DATA TRANSFER REQUIREMENTS BETWEEN THE PLC's AND THE SCADA SYSTEM

Digital inputs and analog inputs to the SCADA system and the software logic generated alarms will be displayed or annunciated at the SCADA workstation as shown on P&IDs, the Instrument Index paragraph 40 06 70-3.03, and this Section. The SCADA system will generate separate alarms if communication is lost with any PLC.

CS34 - EQUIPMENT RUN STATUS

Equipment start/stop control based on run status of other equipment, hardwired or PLC.

CS35 – SEAL FLUSH

Pump seal water flush solenoid valve open/close control based on run status of associated equipment, hardwired. Solenoid should be normally opened type, verify.

CS36 – BEARING FLUSH

Pump bearing water flush solenoid valve open/close control based on run status of associated equipment, hardwired. Solenoid should be normally opened type, verify.

CS37 – BEARING LUBRICATION

Lubrication oil solenoid valve open/close control based on run status of associated equipment, hardwired. Solenoid should be normally opened type, verify.

CS38 – TRAP PRIMER

Trap primer solenoid valve open/close control based on interval and duration timers, hardwired or PLC. Solenoid should be normally closed type, verify.

CS39 – ALTERNATION

Equipment run-time equalization by alternating the lead/lag assignment of two or more equipment items, hardwired or PLC.

1. Hardwired: Alternation occurs when all equipment items stop.
2. PLC: Alternation occurs by SCADA Operator request.

CS40 – PUMP LEAD/LAG SEQUENCING

Pump control in Remote by level switches, hardwired only. Lead pump starts upon medium level. Lag pump starts upon high level. Pumps stop upon low level.

CS41 – PUMP LEVEL CONTROL

Pump control in Remote by level switches, hardwired only. Pump starts upon high level. Pump stops upon low level.

CS42 – PUMP REDUNDANT LEVEL CONTROL

Pump control in Remote by level switches, hardwired only. Pump starts upon high-high level. Pump stops upon low-low level.

CS43 – VALVE OPENS WHEN EQUIPMENT RUNS

Valve open/close control based on run status of other equipment, hardwired or PLC. Typical for spray valves.

CS44 - HYDROPNEUMATIC TANK – ADD AIR

Solenoid Valve control by level and pressure switches, hardwired only. Valve opens upon high level. Valve closes upon high pressure or when level falls below high-level switch setting.

CS45 – HYDROPNEUMATIC TANK – VENT AIR

Solenoid Valve control by level switch, hardwired only. Valve opens upon low level. Valve closes when level rises above low level switch setting.

CS50 – ALARM WHEN NOT RUNNING

PLC generated alarm if unit is not running for 30 seconds, self-resetting.

CS51 – ALTERNATION - SOFTWARE

Equipment run-time equalization by alternating the lead/follow/2nd follow/etc. assignment of two or more pumps, PLC. Alternation occurs when all the pumps in that group stop. Similarly, alternation occurs for the last group of pumps occurs when all the pumps in that group stop. Upon failure of a pump, the standby pump is assigned in place of the failed pump. A typical PLC determined fail alarm for each pump includes:

Hardwired pump equipment related shutdowns (determined by the Process/Mechanical Engineer) including, but not limited to: High motor temperature, VFD fault, and submersible pump moisture detected if applicable. Normally reset at the VFD.

VFD selector switch removal from the REMOTE position. Reset at the selector switch.

Equipment failure refer to CS11 above.

Speed discrepancy in control system speed signal vs. VFD feedback speed, refer to CS61 - Variable Frequency Drive Speed below.

CS61 – VARIABLE FREQUENCY DRIVE SPEED

The minimum pumping speed shall be configured into the VFD for both LOCAL and REMOTE modes, preventing unintentional under-speed and motor overheating in either mode. The PLC shall not be configured to provide an artificial zero of the 4-20 milliamp (mA) or related network control signal, such as 12-20mA to prevent under-speed in VFD REMOTE mode. The requirement to configure the VFD minimum speed setting at the VFD is included in Part 3 of Section 26 29 23.

Although the minimum pumping speed must be configured into the VFD for following the control system speed signal, the feedback speed configuration is a separate VFD setting. This setting shall be left at default, with 4 milliamps or zero network value for 0% speed and 20 milliamps or 100% network value for 100% speed. Display of speed on the SCADA system shall reflect 0% when the pump is stopped and 100% when the pump is running at full speed.

One component of PLC determined pump failure is speed discrepancy as mentioned in CS51 above. The control system speed signal range is instead 0% for minimum pumping speed rather than 0% speed. For comparison with the control system speed signal, the feedback speed range must then be extrapolated from minimum pumping speed to maximum pumping speed for 0% to 100% and clamped to prevent a negative speed value by the PLC. Speed discrepancy in control system speed signal vs. VFD feedback speed is determined by the PLC when they deviate from each other by 10% or more for twenty seconds. The alarm is monitored by and requires reset from the SCADA system.

The PLC minimum feedback pumping speed for the calculation shall match the VFD configured setting for the control signal. Verification of the calculation is performed by comparing PLC calculated speed feedback with PLC control system speed signal at various steady VFD speeds.

CS71 – MOTORIZED VALVE OR GATE CONTROL - ISOLATING

Valve control in REMOTE. When control requests the valve to open, the valve control open command signal is activated until the valve signals opened position. When control requests the valve to close, the valve close command signal is activated until the valve signals closed position. Includes CS75.

CS72 – MOTORIZED VALVE OR GATE CONTROL – MODULATING - ANALOG

Valve control in REMOTE. When control requests a valve position in % opened, the valve control analog signal is set to the % opened required. Includes CS75.

CS73 – MOTORIZED VALVE OR GATE CONTROL – MODULATING - DISCRETE

Valve control in REMOTE. When control requests a valve position in % opened, the valve control open command discrete signal or close command discrete signal is activated until the valve signals the % opened position required. Includes CS75.

CS75 – VALVE OR GATE FAILURE

The failure of control valves or gates will be monitored by the PLC system. Valve or gate actuators will be considered failed under the following conditions:

1. The isolating actuator is in REMOTE and the PLC system attempts to open or close the valve or gate and it does not respond within a defined time period. Time delay field set based on testing, initial setting 60 seconds for valves, 240 seconds for gates.
2. The modulating actuator is in REMOTE and the PLC system attempts to change position of the valve or gate and it does not respond within 2% of valve position within a defined time period. Time delay field set based on testing using a change from 0 to 100% opening, initial setting 60 seconds for valves, 240 seconds for gates.

3.03 CONTROL STRATEGY – FILTER BACKWASH

A. Reference Drawings: 35-PI-16 through 35-PI-21, 35-PI-24, 70-PI-05.

B. System Components
   1. This control strategy will describe the filter backwash process for Filter 1 but is applicable to filters 1 through 6.
   2. 70-B-00010 Blower 1
   3. 70-B-00020 Blower 2

C. Description:
   1. This control strategy describes the filter backwash process which will be run regularly to maintain proper functionality of the filters.
   2. The system is designed such that one filter may be in backwash at any given time and full process flow can be achieved with only 5 operational filters.
   3. There is one duty and one standby blower, only blower 1 will be used for this control strategy description.

D. Control Descriptions:
   1. Drawdown
      a. From the Filter Control screen, the operator selects a filter for backwash and presses start.
      b. The influent valve CV-10011 is given a close command, and the effluent valve holds its current position which initiates the filter drawdown.
      c. As the water level in the filter drops below the trough level, the waste wash water valve CV-10051 is given an open command. This allows water in the gullet to drain.
      d. When the water level in the filter reaches the low level setpoint the effluent valve CV-10021 is given a close command.
   2. Air Scour
      a. The air scour vent valve CV-00017 is given an open command.
      b. The air scour blower is given a start command and blower inlet valve CV-00013 modulates to achieve the desired air flow of 4 SCFM/FT^2.

c. Simultaneously the air scour vent valve CV-00017 is given a close command, and the individual air scour valve CV-10061 is given an open command. This forces the air flow into the filter underdrain to begin the air only scour.

d. The air only scour continues for an operator adjustable time set point (2-3 minutes).

e. The individual backwash valve CV-10031 is given an open command.

f. The Backwash Pumps ramps up to achieve an operator adjustable low backwash rate (6-8 GPM/FT^2) which is controlled via level in the constant head box. The concurrent air/water air scour cycle starts.

g. When the water level in the filter reaches and operator adjustable setpoint (the bottom of the filter troughs) air scour vent valve is given an OPEN command, and the individual air scour valve is given a CLOSE command (simultaneously).

h. The blower is given a STOP command, and the air scour portion of the backwash is concluded.

3. High Backwash

   a. The backwash flow rate is increased to an operator adjustable high backwash flow setpoint (typically 20-22 GPM/FT^2) to achieve 25-30% bed expansion.

   b. When the operator adjustable high backwash timer expires, the filter backwash rate ramps down to a low flow SP of 6-8 GPM/FT^2 to begin the rinse to waste cycle.

4. Rinse to Waste

   a. The rinse to waste (Low Backwash Flowrate) continues for an operator adjustable time setpoint (usually 10 minutes) to allow for one filter box of water to be rinsed from the filter box at a sub fluidized rate.

   b. The backwash flow rate is reduced to zero flow.

   c. The individual backwash valve CV-10031 and waste wash water valve CV-10041 are given simultaneous close commands.

   d. A ready word is sent to the filter control screen indicating to the operator that this filter is now available and ready for service (filter to waste) and the backwash sequence is complete.

5. Setpoints:

Air Scour Air Flow Rate	4 SCFM/FT^2
Air Scour Time	2-3 Minutes
Backwash Flow Rate	6-8 GPM/FT^2
High Backwash Flow Rate	20-22 GPM/FT^2
Rinse to Waste Time	10 Minutes

6. Standard Control Strategies per 40 61 96-3.02:

   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG SYSTEM)

   b. CS18 – DIGITAL ALARM SYSTEM

   c. CS34 – EQUIPMENT RUN STATUS

   d. CS51 – ALTERNATION - SOFTWARE

   e. CS61 – VARIABLE FREQUENCY DRIVE SPEED

   f. CS71 – MOTORIZED VALVE OR GATE CONTROL – ISOLATING

   g. CS72 – MOTORIZED VALVE OR GATE CONTROL – MODULATING – ANALOG

h. CS75 – VALVE OR GATE FAILURE

7. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I3 – HIGH MOTOR TEMPERATURE
   c. I18 – LOW SUCTION TANK LEVEL
8. Software Interlocks:
   a. None.

3.04 CONTROL STRATEGY – FILTER TO WASTE

A. Reference Drawings: 35-PI-16 through 35-PI-21.

B. This control strategy will describe the filter to waste process for filter 1 but is applicable to filters 1 through 6.

C. Description:
   1. The purpose of the Filter to Waste is to ensure that the first water produced by each filter is below the plant particulate and turbidity goals for treated water quality, and well below regulatory guidelines. Well run surface water treatment plants have goals in place to ensure that filtered water quality is always below 0.10 NTU – including at the beginning of each filter run.
   2. Filter to Waste provides the capability, though piping, valving, and procedure to ripen filters and reject water of lesser quality being produced at the beginning of the filter run. The filter to waste stream is directed to a waste wash water collection and recycling facility where it is equalized and returned to the headworks of the plant for retreatment. After water quality is of acceptable quality, the filter is allowed to transition into service by sending water into the finished water system of the facility.

D. Control Descriptions:
   1. From the Filter Control screen, the operator selects an offline filter for service and presses start.
   2. The filter influent valve CV-10011 is given an open command.
   3. After the filter fills to bottom of the established operational level band, the filter to waste valve CV-10041 begins to open and modulates based on the filter level through linear level control. As the level rises, the valve continues to open until equilibrium is achieved.
   4. The filter to waste rate will be equal to the flow being produced at all other filters to ensure when the filter goes online that the flowrate will be unchanged.
   5. The Filter to Waste cycle continues until it meets operator adjustable water quality parameter set points that include:
      a. Initial timer
         1) During this period particle counts and turbidity are ignored to ensure that time is allowed for the ripening spike to occur. During this time the filter cannot go into service.
      b. Particle counts
      c. Turbidity
      d. Ending timer

1) When this time expires, the filter will go into service regardless of any other parameter.

6. When any of the FTW parameters (b – d) are met, the filter transitions into service:
   a. The filter to waste valve CV-10041 receives a close command and simultaneously the effluent valve CV-10021 receives an open command. The effluent valve is then allowed to modulate to maintain the filter level based on linear level control.
   b. When the filter to waste valve CV-10041 achieves a close limit the filter to waste cycle is complete and the ready word in the filter control screen is cleared and the filter is in service.
   c. The filter run timer begins counting.
7. Setpoints:

Filter Level	TBD
Initial Timer	TBD
Particle Count	TBD
Turbidity	TBD
Ending Timer	TBD

8. Standard Control Strategies per 40 61 96-3.02:
   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG SYSTEM)
   b. CS18 – DIGITAL ALARM SYSTEM
   c. CS71 – MOTORIZED VALVE OR GATE CONTROL – ISOLATING
   d. CS72 – MOTORIZED VALVE OR GATE CONTROL – MODULATING – ANALOG
   e. CS75 – VALVE OR GATE FAILURE
9. Standard Interlocks per 40 61 96-3.01:
   a. None.
10. Software Interlocks:
    a. None.

3.05 CONTROL STRATEGY – FLASH MIX

A. Reference Drawings: 35-PI-01 through 35-PI-03.

B. System Components:
   1. 20-P-10010 Flash Mix Pump 1
   2. 20-P-20010 Flash mix Pump 2

C. Description:
   1. Flash mix is vital to ensure that the primary coagulant it dispersed quickly in the steam of flow. It is accomplished by introducing short duration and high intensity mixing up to 1000 g-1. The primary coagulant is introduced at the point of highest energy to ensure thorough dispersion.
   2. There is one duty and one standby pump.

D. Control Descriptions:

1. The Flash Mix Pumps are normally operated in remote mode. In this mode, start/stop and speed is controlled by the PLC.
2. Flash Mix Pumps are arranged in a duty/standby configuration via the HMI.
3. As the plant influent flowrate and/or raw water temperature changes, the pump speed will adjust via PID loop to maintain the energy applied to the water at the desired energy gradient setpoint.
4. Current energy gradient calculation will be displayed on HMI.
5. An operator adjustable dead band setting will be used to prevent pumps from excessive variation based on inherent minor flow meter variations.
6. Setpoints:

Energy Gradient Setpoint	TBD
Pressure Setpoint	TBD

7. Standard Control Strategies per 40 61 96-3.02:
   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   b. CS51 – ALTERNATION - SOFTWARE
   c. CS61 – VARIABLE FREQUENCY DRIVE SPEED
8. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I19 – LOW SUCTION TANK PRESSURE
9. Software Interlocks:
   a. None.

3.06 CONTROL STRATEGY – FLOCCULATORS

A. Reference Drawings: 35-PI-04 through 35-PI-10

B. System Components:
   1. BASIN 1:
      a. 30-MX-11010 FLOCCULATOR 1A
      b. 30-MX-11020 FLOCCULATOR 1B
      c. 30-MX-12010 FLOCCULATOR 2A
      d. 30-MX-12020 FLOCCULATOR 2B
      e. 30-MX-13010 FLOCCULATOR 3A
      f. 30-MX-13020 FLOCCULATOR 3B
   2. BASIN 2:
      a. 30-MX-21010 FLOCCULATOR 1A
      b. 30-MX-21020 FLOCCULATOR 1B
      c. 30-MX-22010 FLOCCULATOR 2A
      d. 30-MX-22020 FLOCCULATOR 2B
      e. 30-MX-23010 FLOCCULATOR 3A
      f. 30-MX-23020 FLOCCULATOR 3B

C. Description:

1. Flocculation follows Flash Mix/Coagulation in the treatment unit process chain. It is primarily a 'mechanical' process in which energy is imparted into the water with mixers to promote collisions between particles, thus allowing the opportunity for very small particles to aggregate and increase in size. There are three stages of flocculation within a single basin. The stages are separated by baffle walls to increase the actual time water spends in the mixing zones. The mixing energy from stage to stage is decreased as floc forms to prevent floc shear; thus, allowing particles to aggregate into a discreet, pinhead size, floc particles that ideal for settling in the sedimentation basins.
2. Control Descriptions:
3. The Flocculators are normally operated in remote mode. In this mode, start/stop and speed is controlled by the PLC.
4. As raw water temperature value changes, the flocculator speed will adjust to maintain the energy applied to the water at the desired energy gradient setpoint.
5. The current energy gradient calculation will be displayed on the HMI for operator information.
6. Setpoints:

Energy Setpoint	TBD
Influent Flow Rate	TBD

7. Standard Control Strategies per 40 61 96-3.02:
   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   b. CS34 – EQUIPMENT RUN STATUS
   c. CS50 – ALARM WHEN NOT RUNNING
   d. CS61 – VARIABLE FREQUENCY DRIVE SPEED
8. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I9 – EMERGENCY STOP
9. Software Interlocks:
   a. None.

3.07 CONTROL STRATEGY – HOSELESS SLUDGE COLLECTORS

A. Reference Drawings: 35-PI-11 through 35-PI-14.

B. System Components:

1. Note that this section will describe the operation of one sludge collector but is applicable to all collectors listed.
2. 40-COL-10010 Solids Collector 1A
3. 40-COL-10020 Solids Collector 1B
4. 40-COL-20010 Solids Collector 1A
5. 40-COL-20020 Solids Collector 2B

C. Description:

1. Solids removal at proper intervals is important to ensure that the sludge collectors continue to work properly. If solids become too thick, the nozzles will become clogged, and flow will be restricted through the sludge collectors causing insufficient solids removal. If this is allowed to happen, the collectors will eventually fail due to over torque and the basin will have to be removed from service. Hoseless collectors require solids to be ≤ 1.5 percent solids; regular samples of the basin solids should be taken and analyzed for percent solids.
2. Best practice for solids removal is for solids accumulation to be calculated in real time within SCADA and for basins to run the collectors based on a known good solids' accumulation setpoint. 500 lbs. per basin is a good starting point but will be tuned by the operator and lab analysis over time. Removing solids too soon is a waste of water and can overwhelm the drying beds. Removing solids too late can cause too much accumulation within the basin and lead to floc carry over, solids turning septic, and solids becoming too dense for the collectors to function as designed.

D. Control Descriptions:
1. The sludge collectors are normally operated in remote mode. In this mode, start/stop is controlled by the PLC.
2. Sludge collectors are started and stopped in response to a vendor calculation of solids accumulated or when the operator adjustable time limit is reached.
3. Sludge valve CV-10011 opens
4. Collectors wait for an operator adjustable delay timer to expire.
5. The hoseless collectors begin a cycle which consists of one full-length travel of the basin.
6. The sludge valve CV-10011 closes.
7. The hoseless collectors return to the retracted home position.
8. The cycle completes and the time and accumulated solids setpoint is reset to zero.
9. Setpoints:

Accumulated Solids	TBD
Delay Timer	TBD
Operation Interval Timer	TBD

10. Standard Control Strategies per 40 61 96-3.02:
    a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
    b. CS34 – EQUIPMENT RUN STATUS
    c. CS71 – MOTORIZED VALVE OR GATE CONTROL - ISOLATING
11. Standard Interlocks per 40 61 96-3.01:
    a. I1 – MOTOR PROTECTION
    b. I9 – EMERGENCY STOP
    c. I14 – OVERTORQUE
12. Software Interlocks:
    a. None.

3.08 CONTROL STRATEGY – ANIONIC POLYMER (PEA) BLENDING/AGING SYSTEM

A. Reference Drawings: 35-PI-28, 35-PI-29.

B. System Components:
   1. 84-P-00010 Neat PEA Mixing Pump
   2. 84-BLND-10010 Polymer Blending Unit 1
   3. 84-BLND-20010 Polymer Blending Unit 2
   4. 84-T-00020 PEA Batch Tank

C. Description:
   1. Anionic Polymers (PEA) have a high molecular weight and are commonly purchased as an emulsion in either 5-gallon totes or 55-gallon drums. Emulsion PEA requires mixing in some type of two stage mixing chambers; that provide a short duration/high intensity mixing, followed by a less intensive lower energy mixing stage. The mixing is designed to allow for the tightly wound polymer chains to 'unravel' prior to reaching the applications point to ensure maximum benefit.
   2. After the polymer has passed through a blending unit, it goes immediately to a day tank 84-T-00020. The purpose of the day tank is to serve as a supply to the downstream blended PEA feeders and to ensure that an adequate supply of chemical is available at peak flow and peak dosages. The day tank also serves another very important purpose, it provides time for the blended PEA to age thereby allowing for the polymer chains to continue to unravel; this enhances the performance of this chemical. Once blended, PEA is susceptible to decay and should not be allowed to sit more than 24 hours. Ideally the batch size should allow for 2-3 batch cycles to run each day to avoid decay and loss of effectiveness.
   3. There is one duty and one standby polymer blending unit.

D. Control Descriptions:
   1. The PEA blending pumps are normally operated in remote mode. In this mode, start/stop is controlled by the PLC.
   2. When the batching tank drops to a Low Level setpoint, the Neat PEA Mixing Pump 84-P-00010 and the Polymer Blending Unit 84-BLND-10010 receive a start command from SCADA.
   3. When the batching tank rises to the High Level setpoint, the blending unit receives a stop command from SCADA
   4. In the event of a blending unit failure, the standby blender automatically is set to duty and runs the batch.
   5. Setpoints:

Concentration	0.15-0.25% solution
Batch Volume	TBD
Blending Water Flow Rate	TBD
Chemical Feed Rate	TBD (mL/min)
Batch Tank Low Level	TBD
Batch Tank High Level	TBD

   6. Standard Control Strategies per 40 61 96-3.02:
      a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
      b. CS34 – EQUIPMENT RUN STATUS
      c. CS41 – PUMP LEVEL CONTROL

d. CS51 – ALTERNATION – SOFTWARE

7. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
8. Software Interlocks:
   a. None

3.09 CONTROL STRATEGY – PEA FILTER AID POLYMER FEEDERS

A. Reference Drawings: 35-PI-15, 35-PI-29.

B. System Components:
   1. 84-P-00020 PEA Feed Pump 1
   2. 84-P-00030 PEA Feed Pump2

C. Description:
   1. In this application, PEA is fed at very small dosages within the filter influent channel, upstream of the filters, to improve particulate removal at the filters. Filter-aids work by increasing the 'stickiness' of the filter media and proves beneficial particularly when plant filtration rates are high or when upstream processes are less than optimal. Dosages range from 0.005 – 0.030. Operators should take great care not to overfeed filter-aid as it can promote rapid head loss accumulation as well as increasing the likelihood of forming mudballs within the filter media.
   2. Continuous and consistent chemical dosing is critical to achieve optimized plant performance. It is important that chemical dosing is done with feeders that are in automatic operation and controlled by SCADA; this allows them to pace off plant flowrates and ensures that th
   3. e chemical dosages remain accurate at all times.
   4. There is one duty and one standby pump.

D. Control Descriptions:
   1. The PEA Feed Pumps are normally operated in remote mode. In this mode, start/stop and speed is controlled by the PLC.
   2. As the plant influent flowrate changes, the chemical feed pump speed will automatically adjust to maintain the desired chemical dosage.
   3. When the operator changes the dosage setpoint the chemical feed pumps speed will automatically adjust to maintain the desired chemical dosage.
   4. By using calibration columns, the operator ensures that chemical feeders are feeding accurately; and as necessary, fine tunes the feed rate using the proportion/ration feature provided within the HMI
   5. In the event of a chemical feed pump failure, the standby pump is automatically set to duty to maintain continuity thus avoiding upsets due to loss of chemical feed.
   6. Setpoints:

Chemical Dosage Rate	TBD
Chemical Concentration	TBD lbs/gallon

7. Standard Control Strategies per 40 61 96-3.02:
    a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
    b. CS34 – EQUIPMENT RUN STATUS
    c. CS51 – ALTERNATION – SOFTWARE
    d. CS61 – VARIABLE FREQUENCY DRIVE SPEED
8. Standard Interlocks per 40 61 96-3.01:
    a. I1 – MOTOR PROTECTION
    b. I2 – HIGH DISCHARGE PRESSURE
    c. I18 – LOW SUCTION TANK LEVEL
9. Software Interlocks:
    a. None.

3.10 CONTROL STRATEGY – PEC COAGULANT AID POLYMER FEEDERS

A. Reference Drawings: NA

B. System Components:
    1. Pumps are existing.

C. Description:
    1. PEC is very beneficial in achieving charge neutralization. PEC is much more effective at reducing *zeta potential* on particulates than primary coagulants and can achieve charge reduction with a fraction of the dosage. Because of this, primary coagulant dosages can be reduced thus causing a net reduction in plant solids production. Lower primary coagulant dosages also reduce the suppression of pH of the treated water.
    2. PEC dosages are adjusted to optimize charge neutralization as measured by a *zeta meter*. Primary coagulant dosages are used in response to the amount of turbidity and organics in the source water; and to form the desired floc characteristics that will produce optimal settled water turbidity.
    3. Continuous and consistent chemical dosing is critical to achieve optimized plant performance. It is important that chemical dosing is done with feeders that are in automatic operation and controlled by SCADA; this allows them to pace off plant flowrates and ensures that the chemical dosages remain accurate at all times.
    4. There is one duty and one standby pump.

D. Control Descriptions:
    1. The PEC Feed Pumps are normally operated in REMOTE mode. In this mode, start/stop and speed is controlled by the PLC.
    2. As the plant influent flowrate changes, the chemical feed pump speed will automatically adjust to maintain the desired chemical dosage.
    3. When the operator changes the dosage setpoint the chemical feed pumps speed will automatically adjust to maintain the desired chemical dosage.
    4. By using calibration columns, the operator ensures that chemical feeders are feeding accurately; and as necessary, fine tunes the feed rate using the proportion/ration feature provided within the HMI

5. In the event of a chemical feed pump failure, the standby pump is automatically set to duty to maintain continuity thus avoiding upsets due to loss of chemical feed.
6. Setpoints:

Chemical Dosage Rate	TBD
Chemical Concentration	TBD lbs/gallon

7. Standard Control Strategies per 40 61 96-3.02:
   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   b. CS34 – EQUIPMENT RUN STATUS
   c. CS51 – ALTERNATION – SOFTWARE
   d. CS61 – VARIABLE FREQUENCY DRIVE SPEED
8. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I18 – LOW SUCTION TANK LEVEL
9. Software Interlocks:
   a. None.

3.11 CONTROL STRATEGY – PRIMARY COAGULANT AID POLYMER FEEDERS

A. Reference Drawings: NA

B. System Components:

C. Pumps are existing.

D. Description:
   1. Primary coagulants are metal salts, usually Iron or Aluminum based chemicals. When fed into the raw water, these chemicals precipitate hydroxides and start the process of coagulation – for example the precipitant formed by ferric products is ferric hydroxide. Charge neutralization is another very important part of coagulation. Charge neutralization can be achieved using primary coagulants, but it is more effective when used together with cationic polymers.
   2. Continuous and consistent chemical dosing is critical to achieve optimized plant performance. It is important that chemical dosing is done with feeders that are in automatic operation and controlled by SCADA; this allows them to pace off plant flowrates and ensures that the chemical dosages remain accurate at all times.
   3. There is one duty and one standby pump.

E. Control Descriptions:
   1. The Primary Coagulant Feed Pumps are normally operated in REMOTE mode. In this mode, start/stop and speed is controlled by the PLC.
   2. As the plant influent flowrate changes, the chemical feed pump speed will automatically adjust to maintain the desired chemical dosage.
   3. When the operator changes the dosage setpoint the chemical feed pumps speed will automatically adjust to maintain the desired chemical dosage.

4. By using calibration columns, the operator ensures that chemical feeders are feeding accurately; and as necessary, fine tunes the feed rate using the proportion/ration feature provided within the HMI
5. In the event of a chemical feed pump failure, the standby pump is automatically set to duty to maintain continuity thus avoiding upsets due to loss of chemical feed.
6. Setpoints:

Chemical Dosage Rate	TBD
Chemical Concentration	TBD lbs/gallon

7. Standard Control Strategies per 40 61 96-3.02:
   a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   b. CS34 – EQUIPMENT RUN STATUS
   c. CS51 – ALTERNATION – SOFTWARE
   d. CS61 – VARIABLE FREQUENCY DRIVE SPEED
8. Standard Interlocks per 40 61 96-3.01:
   a. I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I18 – LOW SUCTION TANK LEVEL
9. Software Interlocks:
   a. None.

3.12 CONTROL STRATEGY – PEA FLOCCULANT AID POLYMER FEEDER

A. Reference Drawings: 35-PI-30.

B. System Components:

C. 84-P-00040 PEA Feed Pump 3

D. Description:
1. PEA is fed at the midpoint of flocculation stages to enhance the formation of floc particles within the floc basins and potentially improve settled water turbidities. Typical dosages can range from 0.10 – 1.0 PPM.
2. Continuous and consistent chemical dosing is critical to achieve optimized plant performance. It is important that chemical dosing is done with feeders that are in automatic operation and controlled by SCADA; this allows them to pace off plant flowrates and ensures that the chemical dosages remain accurate at all times.
3. Control Descriptions:
4. The PEA Feed Pump is normally operated in remote mode. In this mode, start/stop and speed is controlled by the PLC.
5. As the plant influent flowrate changes, the chemical feed pump speed will automatically adjust to maintain the desired chemical dosage.
6. When the operator changes the dosage setpoint the chemical feed pumps speed will automatically adjust to maintain the desired chemical dosage.

7. By using calibration columns, the operator ensures that chemical feeders are feeding accurately; and as necessary, fine tunes the feed rate using the proportion/ration feature provided within the HMI
8. Setpoints:

Chemical Dosage Rate	TBD
Chemical Concentration	TBD lbs/gallon

9. Standard Control Strategies per 40 61 96-3.02:
    a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
    b. CS34 – EQUIPMENT RUN STATUS
    c. CS61 – VARIABLE FREQUENCY DRIVE SPEED
10. Standard Interlocks per 40 61 96-3.01:
    a. I1 – MOTOR PROTECTION
    b. I2 – HIGH DISCHARGE PRESSURE
    c. I18 – LOW SUCTION TANK LEVEL
11. Software Interlocks:
    a. None.

3.13 CONTROL STRATEGY – PEA SOLIDS HANDLING POLYMER FEEDER

A. Reference Drawings: 35-PI-30.

B. System Components:

C. 84-P-00060 PEA Feed Pump 5

D. Description:

1. In this application, PEA is fed into streams leading to clarifiers or solids settling basins to improve the speed and efficiency of the settling process and the clarity of the settled water being returned to the headworks of the plant during the recycling process. Typical dosages range between 0.10 – 1.0 PPM.
1. Continuous and consistent chemical dosing is critical to achieve optimized plant performance. It is important that chemical dosing is done with feeders that are in automatic operation and controlled by SCADA; this allows them to pace off plant flowrates and ensures that the chemical dosages remain accurate at all times.
2. Control Descriptions:
3. The PEA Feed Pump is normally operated in remote mode. In this mode, start/stop and speed is controlled by the PLC.
4. As the plant influent flowrate changes, the chemical feed pump speed will automatically adjust to maintain the desired chemical dosage.
5. When the operator changes the dosage setpoint the chemical feed pumps speed will automatically adjust to maintain the desired chemical dosage.
6. By using calibration columns, the operator ensures that chemical feeders are feeding accurately; and as necessary, fine tunes the feed rate using the proportion/ration feature provided within the HMI
7. Setpoints:

Chemical Dosage Rate	TBD
Chemical Concentration	TBD lbs/gallon

8. Standard Control Strategies per 40 61 96-3.02:
    a. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
    b. CS34 – EQUIPMENT RUN STATUS
    c. CS61 – VARIABLE FREQUENCY DRIVE SPEED
9. Standard Interlocks per 40 61 96-3.01:
    a. I1 – MOTOR PROTECTION
    b. I2 – HIGH DISCHARGE PRESSURE
    c. I18 – LOW SUCTION TANK LEVEL
10. Software Interlocks:
    a. None.

E. CONTROL STRATEGy – infiltration gallery

F. Reference Drawings: 01-PI-01.

G. System Components:

H. 01-P-00010 Infiltration Gallery Pump 1

I. 01-P-00020 Infiltration Gallery Pump 2

J. Description:
1. [This process does this, for this reason].
2. [Capacities, considerations, and limits from the design report/technical memorandum].
3. [There are [two] duty and [one] standby [pump].]
4. [The pumps operate in lead and follow sequencing.]

K. Control Descriptions:
1. The [_____] are normally operated in REMOTE mode. In this mode, start/stop [and speed] is controlled by the PLC.
2. [_____] are started and stopped [by the Operator] [to maintain/in response to _____].
3. [Speed is controlled to maintain/in response to _____].
4. In the event of utility power failure, [_____] will stop due to loss of power. If [_____] are operating on standby power and utility power is restored, the [_____] will be called to stop when the automatic transfer [switch][controller] returns to the utility power position. [This is required as the transfer [switch][controller] does not provide for phase synchronized make-before-break transfer from standby to utility power, to prevent motor back-emf from tripping circuit breakers.]
5. [Pumps will restart on standby or return to utility power in the same mode, number of pumps, and speeds as they were running before. Pumps will be delay-started by the PLC, however. The Lead pump will be restarted 5 seconds after power availability, and the Lag 1 pump 15 seconds after (if called previously).]

6. [The standby generator is sized to operate two duty pumps, with one as standby. The control system shall not attempt automatic start or permit SCADA manual start of all three pumps when on standby power.]
7. Setpoints:

Lead Pump Pressure Off Setpoint	176 psig default, range 160 to 180 adjustable
Lead Pump Pressure On Delay Setpoint	60 sec. fixed
Lead Pump Pressure On Setpoint	171 psig default, range 160 to 180 adjustable
Lag 1 Pump Pressure Off Setpoint	171 psig default, range 160 to 180 adjustable
Lag Pump Pressure On Delay Setpoint	60 sec. fixed
Lag 1 Pump Pressure On Setpoint	166 psig default, range 160 to 180 adjustable
Pressure Setpoint	170 psig default, range 160 psig to 180 psig adjustable

8. Standard Control Strategies per 40 61 96-3.02:
   a. [CS2 – FLOW TOTALIZATION
   b. CS11 – GENERAL READY, RUNNING AND FAILURE SYSTEM
   c. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   d. CS19 – DATA ARCHIVING HISTORIAN AND HISTORICAL FUNCTIONS
   e. CS51 – ALTERNATION – SOFTWARE
   f. CS61 – VARIABLE FREQUENCY DRIVE SPEED]
9. Standard Interlocks per 40 61 96-3.01:
   a. [I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I3 – HIGH MOTOR TEMPERATURE
   d. I18 – LOW SUCTION TANK LEVEL (PRESSURE)]
10. Software Interlocks:
    a. [None.] [_____].

3.14 CONTROL STRATEGY – SODIUM HYPOCHLORITE FEED PUMPS

A. Reference Drawings: 03-PI-03, 03-PI-04.

B. System Components:

C. 89-P-00060 Sodium Hypochlorite Pump 1

D. 89-P-00070 Sodium Hypochlorite Pump 2

E. 89-P-00080 Sodium Hypochlorite Pump 3

F. 89-P-00090 Sodium Hypochlorite Pump 4

G. 89-P-00090 Sodium Hypochlorite Pump 5

H. 89-P-00090 Sodium Hypochlorite Pump 6

I. Description:
   1. [This process does this, for this reason].

2. [Capacities, considerations, and limits from the design report/technical memorandum].
3. [There are [two] duty and [one] standby [pump].]
4. [The pumps operate in lead and follow sequencing.]

J. Control Descriptions:
1. The [_____] are normally operated in REMOTE mode. In this mode, start/stop [and speed] is controlled by the PLC.
2. [_____] are started and stopped [by the Operator] [to maintain/in response to _____].
3. [Speed is controlled to maintain/in response to _____].
4. In the event of utility power failure, [_____] will stop due to loss of power. If [_____] are operating on standby power and utility power is restored, the [_____] will be called to stop when the automatic transfer [switch][controller] returns to the utility power position. [This is required as the transfer [switch][controller] does not provide for phase synchronized make-before-break transfer from standby to utility power, to prevent motor back-emf from tripping circuit breakers.]
5. [Pumps will restart on standby or return to utility power in the same mode, number of pumps, and speeds as they were running before. Pumps will be delay-started by the PLC, however. The Lead pump will be restarted 5 seconds after power availability, and the Lag 1 pump 15 seconds after (if called previously).]
6. [The standby generator is sized to operate two duty pumps, with one as standby. The control system shall not attempt automatic start or permit SCADA manual start of all three pumps when on standby power.]
7. Setpoints:

Lead Pump Pressure Off Setpoint	176 psig default, range 160 to 180 adjustable
Lead Pump Pressure On Delay Setpoint	60 sec. fixed
Lead Pump Pressure On Setpoint	171 psig default, range 160 to 180 adjustable
Lag 1 Pump Pressure Off Setpoint	171 psig default, range 160 to 180 adjustable
Lag Pump Pressure On Delay Setpoint	60 sec. fixed
Lag 1 Pump Pressure On Setpoint	166 psig default, range 160 to 180 adjustable
Pressure Setpoint	170 psig default, range 160 psig to 180 psig adjustable

8. Standard Control Strategies per 40 61 96-3.02:
   a. [CS2 – FLOW TOTALIZATION
   b. CS11 – GENERAL READY, RUNNING AND FAILURE SYSTEM
   c. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   d. CS19 – DATA ARCHIVING HISTORIAN AND HISTORICAL FUNCTIONS
   e. CS51 – ALTERNATION – SOFTWARE
   f. CS61 – VARIABLE FREQUENCY DRIVE SPEED]
9. Standard Interlocks per 40 61 96-3.01:
   a. [I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I3 – HIGH MOTOR TEMPERATURE
   d. I18 – LOW SUCTION TANK LEVEL (PRESSURE)]

10. Software Interlocks:
    a. [None.] [_____].

3.15 CONTROL STRATEGY – WASTE BACKWASH WATER CLARIFIER

A. Reference Drawings: 35-PI-34, 60-PI-01, 60-PI-02.

B. System Components:

C. Collection Box

D. 60-CL-00013 Waste Backwash Water Clarifier

E. 60-P-00010 Recycle Pump 1

F. 60-P-00020 Recycle Pump 2

G. Description:
1. This process is designed to collect waste streams from various plant processes such as spent filter backwash water, filter to waste, and water from the basin drain system and treat it sufficiently to be recycled to the raw water intake.
2. [Capacities, considerations, and limits from the design report/technical memorandum].
3. There is one duty and one standby pump in the recycled water pump station.

H. Control Descriptions:
1. The [_____] are normally operated in REMOTE mode. In this mode, start/stop [and speed] is controlled by the PLC.
2. [_____] are started and stopped [by the Operator] [to maintain/in response to _____].
3. [Speed is controlled to maintain/in response to _____].
4. In the event of utility power failure, [_____] will stop due to loss of power. If [_____] are operating on standby power and utility power is restored, the [_____] will be called to stop when the automatic transfer [switch][controller] returns to the utility power position. [This is required as the transfer [switch][controller] does not provide for phase synchronized make-before-break transfer from standby to utility power, to prevent motor back-emf from tripping circuit breakers.]
5. [Pumps will restart on standby or return to utility power in the same mode, number of pumps, and speeds as they were running before. Pumps will be delay-started by the PLC, however. The Lead pump will be restarted 5 seconds after power availability, and the Lag 1 pump 15 seconds after (if called previously).]
6. [The standby generator is sized to operate two duty pumps, with one as standby. The control system shall not attempt automatic start or permit SCADA manual start of all three pumps when on standby power.]
7. Setpoints:

Lead Pump Pressure Off Setpoint	176 psig default, range 160 to 180 adjustable
Lead Pump Pressure On Delay Setpoint	60 sec. fixed
Lead Pump Pressure On Setpoint	171 psig default, range 160 to 180 adjustable

Lag 1 Pump Pressure Off Setpoint	171 psig default, range 160 to 180 adjustable
Lag Pump Pressure On Delay Setpoint	60 sec. fixed
Lag 1 Pump Pressure On Setpoint	166 psig default, range 160 to 180 adjustable
Pressure Setpoint	170 psig default, range 160 psig to 180 psig adjustable

8. Standard Control Strategies per 40 61 96-3.02:
   a. [CS2 – FLOW TOTALIZATION
   b. CS11 – GENERAL READY, RUNNING AND FAILURE SYSTEM
   c. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   d. CS19 – DATA ARCHIVING HISTORIAN AND HISTORICAL FUNCTIONS
   e. CS51 – ALTERNATION – SOFTWARE
   f. CS61 – VARIABLE FREQUENCY DRIVE SPEED]
9. Standard Interlocks per 40 61 96-3.01:
   a. [I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I3 – HIGH MOTOR TEMPERATURE
   d. I18 – LOW SUCTION TANK LEVEL (PRESSURE)]
   e. Software Interlocks:

   [None.] [_____].

3.16 CONTROL STRATEGY – CLEARWELL PUMP STATION

A. Reference Drawings: 70-PI-03 through 70-PI-07

B. System Components:

C. 73-PI-00010 Plant Water Pump 1

D. 73-PI-00020 Plant Water Pump 2

E. 71-PI-00010 Backwash Supply Pump 1

F. 71-PI-00020 Backwash Supply Pump 2

G. 71-PI-00030 Backwash Supply Pump 3

H. 70-P-00020 Structural Underdrain Pump Station Pump 1

I. 70-P-00030 Structural Underdrain Pump Station Pump 2

J. Description:
   1. [This process does this, for this reason].
   2. [Capacities, considerations, and limits from the design report/technical memorandum].
   3. [There are [two] duty and [one] standby [pump].]
   4. [The pumps operate in lead and follow sequencing.]

K. Control Descriptions:

1. The [_____] are normally operated in REMOTE mode. In this mode, start/stop [and speed] is controlled by the PLC.
2. [_____] are started and stopped [by the Operator] [to maintain/in response to _____].
3. [Speed is controlled to maintain/in response to _____].
4. In the event of utility power failure, [_____] will stop due to loss of power. If [_____] are operating on standby power and utility power is restored, the [_____] will be called to stop when the automatic transfer [switch][controller] returns to the utility power position. [This is required as the transfer [switch][controller] does not provide for phase synchronized make-before-break transfer from standby to utility power, to prevent motor back-emf from tripping circuit breakers.]
5. [Pumps will restart on standby or return to utility power in the same mode, number of pumps, and speeds as they were running before. Pumps will be delay-started by the PLC, however. The Lead pump will be restarted 5 seconds after power availability, and the Lag 1 pump 15 seconds after (if called previously).]
6. [The standby generator is sized to operate two duty pumps, with one as standby. The control system shall not attempt automatic start or permit SCADA manual start of all three pumps when on standby power.]
7. Setpoints:

Lead Pump Pressure Off Setpoint	176 psig default, range 160 to 180 adjustable
Lead Pump Pressure On Delay Setpoint	60 sec. fixed
Lead Pump Pressure On Setpoint	171 psig default, range 160 to 180 adjustable
Lag 1 Pump Pressure Off Setpoint	171 psig default, range 160 to 180 adjustable
Lag Pump Pressure On Delay Setpoint	60 sec. fixed
Lag 1 Pump Pressure On Setpoint	166 psig default, range 160 to 180 adjustable
Pressure Setpoint	170 psig default, range 160 psig to 180 psig adjustable

8. Standard Control Strategies per 40 61 96-3.02:
   a. [CS2 – FLOW TOTALIZATION
   b. CS11 – GENERAL READY, RUNNING AND FAILURE SYSTEM
   c. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
   d. CS19 – DATA ARCHIVING HISTORIAN AND HISTORICAL FUNCTIONS
   e. CS51 – ALTERNATION – SOFTWARE
   f. CS61 – VARIABLE FREQUENCY DRIVE SPEED]
9. Standard Interlocks per 40 61 96-3.01:
   a. [I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I3 – HIGH MOTOR TEMPERATURE
   d. I18 – LOW SUCTION TANK LEVEL (PRESSURE)]
10. Software Interlocks:
    a. [None.] [_____].

3.17 CONTROL STRATEGY – CLEARWELL

A. Reference Drawings: 70-PI-01

B. System Components:

C. 70-PI-00040 Clearwell Drain Pump 1

D. 70-PI-00050 Clearwell Drain Pump 2

E. Description:

1. [This process does this, for this reason].
2. [Capacities, considerations, and limits from the design report/technical memorandum].
3. [There are [two] duty and [one] standby [pump].]
4. [The pumps operate in lead and follow sequencing.]

F. Control Descriptions:

1. The [_____] are normally operated in REMOTE mode. In this mode, start/stop [and speed] is controlled by the PLC.
2. [_____] are started and stopped [by the Operator] [to maintain/in response to _____].
3. [Speed is controlled to maintain/in response to _____].
4. In the event of utility power failure, [_____] will stop due to loss of power. If [_____] are operating on standby power and utility power is restored, the [_____] will be called to stop when the automatic transfer [switch][controller] returns to the utility power position. [This is required as the transfer [switch][controller] does not provide for phase synchronized make-before-break transfer from standby to utility power, to prevent motor back-emf from tripping circuit breakers.]
5. [Pumps will restart on standby or return to utility power in the same mode, number of pumps, and speeds as they were running before. Pumps will be delay-started by the PLC, however. The Lead pump will be restarted 5 seconds after power availability, and the Lag 1 pump 15 seconds after (if called previously).]
6. [The standby generator is sized to operate two duty pumps, with one as standby. The control system shall not attempt automatic start or permit SCADA manual start of all three pumps when on standby power.]
7. Setpoints:

Lead Pump Pressure Off Setpoint	176 psig default, range 160 to 180 adjustable
Lead Pump Pressure On Delay Setpoint	60 sec. fixed
Lead Pump Pressure On Setpoint	171 psig default, range 160 to 180 adjustable
Lag 1 Pump Pressure Off Setpoint	171 psig default, range 160 to 180 adjustable
Lag Pump Pressure On Delay Setpoint	60 sec. fixed
Lag 1 Pump Pressure On Setpoint	166 psig default, range 160 to 180 adjustable
Pressure Setpoint	170 psig default, range 160 psig to 180 psig adjustable

8. Standard Control Strategies per 40 61 96-3.02:
   a. [CS2 – FLOW TOTALIZATION
   b. CS11 – GENERAL READY, RUNNING AND FAILURE SYSTEM

c. CS15 – GENERAL PROCESS CONTROL FUNCTION (ANALOG) SYSTEM
d. CS19 – DATA ARCHIVING HISTORIAN AND HISTORICAL FUNCTIONS
e. CS51 – ALTERNATION – SOFTWARE
f. CS61 – VARIABLE FREQUENCY DRIVE SPEED]

9. Standard Interlocks per 40 61 96-3.01:
   a. [I1 – MOTOR PROTECTION
   b. I2 – HIGH DISCHARGE PRESSURE
   c. I3 – HIGH MOTOR TEMPERATURE
   d. I18 – LOW SUCTION TANK LEVEL (PRESSURE)]
10. Software Interlocks:
   a. [None.] [_____].

END OF SECTION

SECTION 40 62 00

COMPUTER SYSTEM HARDWARE AND ANCILLARIES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies industrial computer software and hardware systems for location in wet and corrosive process environments.

1.02 QUALITY ASSURANCE

A. References
   1. Refer to Section 40 61 13, References.

B. Systems Responsibility
   1. Refer to Section 40 61 13, Corrosive Locations.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Manufacturer's product literature for all software systems, marked to show products included.
   3. Manufacturer's product literature for all hardware components, marked to show products included.

PART 2 PRODUCTS

2.01 INDUSTRIAL COMPUTER WORKSTATIONS (PANEL MOUNT)

A. Heavy Duty Industrial PC Hardware:
   1. Provide Protech Solutions, Advantech, or Owner-approved panel mounted workstations with factory installed components, licensed in the Owner's name
   2. NEMA 4X exposed parts
   3. IP65 compliant front panel protection

4. Operating temperature: 0 to 50ºC
5. Processor Controller:
    a. Intel Core i7 series CPU, or approved equal, fanless design
    b. 16 GB DDR4 RAM
    c. 256 GB SSD
    d. 2 x 10/100/1000 Mbps Ethernet LAN port
    e. Four USB 3.0 ports
    f. Two RS-232 serial ports
    g. Minimum one spare PCI-e slot
6. Minimum 21" diagonal color display, touchscreen, 16:9
7. Projected capacitive
8. Power: 120VAC
9. Optical Mouse with scroll for configuration purposes
10. Two year warranty from shipment date.

B. Enclosure:
    1. Enclosures for the panel-mounted PCs shall be in accordance with Section 40 67 00, Control System Equipment Panels and Racks

C. Operating System Software:
    1. Provide one of the following for each workstation, licensed in the Owner's name. Request licensee name and address from the Construction Manager prior to ordering.
    2. Windows 11 IoT Enterprise (64-bit) latest version.

2.02 WORKSTATION SOFTWARE

A. General:
    1. License all software products in the Owner's name. Request licensee name and address from the Construction Manager prior to ordering. Provide latest versions.

B. OIS Software:
    1. Refer to Section 40 68 13.

2.03 SOURCE QUALITY CONTROL

A. The Owner and Construction Manager require the specified manufacturers to provide the equipment and/or products to be furnished under this section. The Owner and Construction Manager believe the manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed to mean that the named manufacturer's standard product will comply with the requirements of this Section. Manufacturers shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience.

2.04 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00.

B. Operation And Maintenance Information:
   1. One set of all software and hardware manuals shall be provided at time of delivery to the Owner, including maintenance information. Include written warranty and final reviewed submittal.

PART 3 EXECUTION

3.01 GENERAL

A. Provide workstations and equipment as shown. Troubleshoot and repair any intermittent or inoperative network connections.

3.02 SOFTWARE INSTALLATION

A. Provide workstation operating system software pre-loaded by the workstation manufacturer.

B. Programmer:
   1. Industrial computer workstation (ICW) software installation.

3.03 APPLICATIONS CONFIGURATION

A. Programmer:
   1. Configure ICW operating system software.
   2. Configure ICW application software.

END OF SECTION

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SECTION 40 63 43

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope

1. This Section specifies requirements for programmable logic controllers (PLC) designed to execute discrete and continuous control logic with high reliability in industrial applications. Enclosures and components are specified in Section 40 67 00.
2. All PLCs provided for this project shall comply with the requirements of this Section. PLCs provided with equipment specified in Divisions 23, 41, 43, 44, and 46 are provided by the Contractor, unless specified otherwise in the project documentation.

B. PLC Schedule

PLC Designation	Testing	Spares Required?
35-PLC-9000	Factory Acceptance	Yes
35-PLC-9001	Factory Acceptance	Yes
35-PLC-9002	Factory Acceptance	Yes
35-PLC-9003	Factory Acceptance	Yes
35-PLC-9004	Factory Acceptance	Yes
35-PLC-9005	Factory Acceptance	Yes
35-PLC-9006	Factory Acceptance	Yes
70-PLC-9000	Factory Acceptance	Yes
87-PLC-9000	Factory Acceptance	Yes

C. General Requirements:

1. General requirements shall be as specified in Sections 40 61 13.01 and 40 67 00.

1.02 QUALITY ASSURANCE

A. References

1. This Section contains references to the following documents or documents listed in Sections 26 05 00, 40 61 13, and 40 67 00. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEC 61131-3	Programmable Controllers – Part 3: Programming Languages
NEMA IA 2.2	Programmable Controllers – Equipment Requirements and Tests
NEMA IA 2.3	Programmable Controllers – Programming Languages

B. Systems Integrator
   1. Responsibilities and qualifications shall be as specified in Section 40 61 13.

C. Factory Acceptance Tests (FAT):
   1. FAT are specified in Section 40 61 21 and scheduled in the PLC Schedule.
      a. Submit factory test forms for approval prior to tests.
      b. Provide all expenses for one Owner staff member and one Engineer staff member to witness factory testing. Travel shall be during business hours on weekdays.
      c. After FAT, complete programmable logic controllers including chassis, I/O modules, associated cabling, and miscellaneous hardware shall be turned over to the Owner during construction to facilitate Owner-directed programming and configuration.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Sections 01 33 00 and 40 61 13:

B. Shop Drawings:
   1. Submit under Section 40 67 00, including:
      a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole.
      b. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
      c. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the Specifications.
      d. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Submittal requirements per Section 40 67 00 for the equipment specified herein

3. PLC Input/Output (I/O) loop diagram drawings
4. Internal power distribution schematic diagram drawings
5. PLC power supply loading calculations
6. List of spare parts to be provided

C. FAT Schedule And Forms
1. Submit under Section 40 61 21 and per the requirements of this Section

D. Operating and Maintenance Information:
1. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following for the PLC system:
a. Manufacturer, Representative, and Supplier contact information.
b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
1) Safety precautions
2) Environmental conditions
3) Troubleshooting guides and diagnostic techniques
4) Component connection diagrams
5) Removal and replacement instructions
c. Warranty information
d. Final reviewed submittal
e. As-built drawings with record of switch and jumper settings for all components
f. List of spare parts provided

PART 2 PRODUCTS

2.01 GENERAL

A. Manufacturer
1. The Owner and Construction Manager require the specified Contractor to provide the manufacturer-supplied equipment and/or products to be furnished under this Section.
2. Manufacturers and models shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience, no substitutions are permitted.

B. Materials
1. Equipment and/or products shall be new and unused at the time of system assembly.

C. Controller conforming to NEMA IA 2.2, and with required memory and functional capacity to perform specified sequence of operation with scheduled input and output points.
1. RFI/EMI Susceptibility: MIL STD 461B CS02.
2. Showering Arc Test: NEMA Pub No ICS2-230.42.
3. Surge Withstand: ANSI C37.90a.
4. RFI Immunity: IEC 801-3.

5. Ground Continuity: IEC 801-5.
6. Electrostatic Discharge: IEC 801-2.
7. Electromagnetic Field: IEC 61000-4-3.
8. Fast transients: IEC 61000-4-4.

2.02 PROGRAMMABLE LOGIC CONTROLLER

A. Manufacturer:
   1. Schneider Electric Modicon M580 and X80 platforms
   2. Schneider Electric Modicon M340 and X80 platforms
   3. No substitutions

B. Networking Connections: Provide communication interfaces, network cables, taps, terminators, power supplies, and accessories for a complete operating network.
   1. Modbus TCP
   2. ASCII RS485 to particle counter(s)

C. Processor:
   1. With ethernet port(s) and serial port(s) dedicated solely for programming use, minimum 200k bytes (8 bit) for IEC 1131 control programs, and 24k words (16-bit) for storage of data in battery-backed RAM memory. Provide additional serial communications adapters required for other serial interfacing. Include real-time clock.

D. Input and Output Modules:
   1. Discrete Inputs: BMXDAI1604H
   2. Discrete Outputs: BMXDDO1602H
   3. Analog Inputs: BMXAMI0810H
   4. Analog Outputs: BMXAMO0410H
   5. I/O module terminations:
      a. By manufacturer to match module.
   6. I/O module interface modules:
      a. Provide as necessary including cabling to interface all I/O to processor.
   7. Spare Input/Outputs:
      a. The greater of a minimum one channel or 15% of each type provided per control panel.

E. Power Supplies: Schneider Electric Modicon BMXCPS3020H

F. Miscellaneous:
   1. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

2.03 PROGRAMMING SOFTWARE

A. The following software shall be provided by the Systems Integrator for this project.

B. Programmable Logic Controller
   1. PLC Manufacturer:
      a. Schneider Electric EcoStruxture Control Expert (formerly Unity Pro)
   2. Licenses: Provide 1 license to the Owner

2.04 SPARE PARTS

A. Programmable Logic Controller
   1. One of each unique processor card
   2. One of each unique remote I/O and communication card
   3. One for each ten I/O card, minimum of one for each unique I/O card
   4. One of each unique power supply
   5. One of each unique pre-fabricated cable

2.05 CONTROL PANEL FABRICATION

A. Refer to Section 40 67 00.

B. Detail shop drawings showing field connections and any terminal block jumpering required.

C. Terminate all used and spare I/O wiring to terminal blocks.

D. Provide terminal blocks for field connections to PLC discrete inputs:
   1. One fused terminal with LED for each group of 8 inputs, connected to control power
   2. Fused terminal connected to eight terminal blocks to provide power to each field input circuit
   3. One terminal per PLC input
   4. One common terminal for each group of 8 inputs, connected to control power common

E. Provide terminal blocks for field connections to PLC discrete outputs:
   1. One fused terminal with LED for each output, connected to control power
   2. Provide interposing relay for each solid-state PLC output. Connect output and control power common to relay coil
   3. One common terminal for each output, connected to control power common

F. Provide terminal blocks for field connections to PLC analog inputs:
   1. One fused terminal with LED for each input, connected to 24VDC
   2. Two terminals per PLC input
   3. One common terminal for each input, connected to 24VDC common
   4. One ground terminal for each input shield, connected to signal ground bus.
   5. Two surge protecting terminals for each field mounted instrument or equipment, grounded to the frame ground bus.

G. Provide terminal Blocks for field connections to PLC Analog Outputs:
   1. One fused terminal with LED for each output, connected to 24VDC.

2. Two terminals per PLC output.
3. One common terminal for each output, connected to 24VDC common
4. One ground terminal for each output shield, connected to signal ground bus
5. Two surge protecting terminals for field mounted equipment, grounded to the frame ground bus

2.06 PRODUCT DATA

A. The following Product Data shall be provided in accordance with Section 01 33 00.

B. FAT Results:
   1. Submit under Section 40 61 21 and per the requirements of this Section.

C. Operating and Maintenance Information:
   1. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following.
      a. Manufacturer, representative, and supplier contact information.
      b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
         1) Safety precautions
         2) Environmental conditions
         3) Troubleshooting guides and diagnostic techniques
         4) Component connection diagrams
         5) Removal and replacement instructions
      c. Warranty information
      d. Final reviewed submittal
      e. As-built drawings with record of switch and jumper settings for all components

D. PLC Program – Systems Integrator
   1. Provide the as-built programmable controller program prepared using the software type specified in this specification and per Section 40 68 03

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 40 67 00

B. Connect input and output devices to the PLC via control panel terminal blocks. Direct wiring directly to the PLC is prohibited.

3.02 FIELD INSPECTION AND TESTING

A. Refer to Section 40 67 00

B. Equipment manufacturer and Systems Integrator: The supplier of each PLC system shall provide a qualified service representative to perform the following:
   1. Inspect the PLC installation including I/O and network systems, hardware configuration switch and jumper settings.
   2. Monitor all PLC system diagnostic indicators, both hardware and software, and certify that the PLC system performance meets or exceeds the manufacturer's published specifications.
   3. Assist in all testing. The Systems Integrator will provide a minimum of two man-weeks on-site for each PLC I/O enclosure.
   4. Modify PLC programs as required
   5. Certify in writing to the Construction Manager that the PLC system has been installed and configured in accordance with the manufacturer's published guidelines.

C. Contractor
   1. Fault or trouble conditions shall be investigated and resolved by the Contractor to the satisfaction of the PLC supplier.

3.03 TRAINING

A. Operations and Troubleshooting
   1. The Systems Integrator shall conduct application program maintenance, modification, and re-loading training conforming to the requirements of Section 01 79 00. A minimum of four man-hours on-site including training materials and expenses shall be provided for four maintenance personnel.

B. PLC Programming
   1. Off-site training shall be provided for the Owner's personnel on the operation and troubleshooting of the PLC system and fundamental programming techniques. Training shall be conducted by a certified instructor in the direct employ of the PLC manufacturer.
   2. The training shall be structured as a lecture/lab course with hands-on lab exercises utilizing PLC system hardware similar to the hardware installed as work of this contract. Hardware simulators and programming terminals shall be furnished by the PLC manufacturer. A minimum of 3 days of formal training shall be presented.
   3. Travel shall occur one day before and one day after training. Contractor shall include the cost of training and all expenses for 2 personnel.

END OF SECTION

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SECTION 40 66 00

NETWORK AND COMMUNICATION SYSTEMS TESTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies updates to the facility's existing data communication network configuration verification and validation including performance testing with certified testing equipment. This section specifies the documentation of network configuration verification and data communication validation for the networks shown on the drawings. This specification does not address testing the existing network and communications system(s).

B. This section specifies the work that service firms with the technical staff trained on network system test equipment, test results interpretation, and report preparation for network systems. Firms shall be EIA/TIA members and meet the performance and safety requirements of local laws, regulations, codes, and standards governing the work.

C. The firms shall demonstrate network systems training on:
   1. Modbust TCP protocol

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
EIA	Electronics Industries Alliance
TIA	Telecommunications Industry Association
NEC	National Electrical Code
NESC	National Electrical Safety Code

1.03 SUBMITTALS

A. Submit the information in of this specification in accordance with Section 01 33 00

1.04 PROJECT / SITE CONDITIONS

A. The equipment shall be designed and manufactured to meet the specified requirements of Section 01 11 80 and 01 73 23 for environmental and seismic conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND SERVICE PROVIDERS

A. Candidate manufacturers and service providers include:
   1. Schneider Electric/Modicon
   2. Or approved equal

2.02 PRODUCT DATA

A. Applicable information shall be provided in the product submittal, including:
   1. Test Equipment calibration certification for any testing devices used.
   2. Network block diagram and network routing site plan drawings.
   3. Testing Services Report sealed by a Registered Electrical or Control System Engineer.

PART 3 EXECUTION

3.01 ONSITE NETWORK INSPECTION AND VALIDATION SERVICES:

A. Coordinate the network inspection, validation and testing services with the Construction Manager.

3.02 FIELD TESTING

A. The network equipment shall be tested in accordance with this specification and service provider's standard procedures.
   1. Test operation of communication ports
   2. Test data communication circuit from end-to-end for each link of the network
   3. Test for validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain
   4. Test for validation of snooping within each domain
   5. Test the performance of the network

3.03 FIELD VERIFICATION

A. The network equipment shall be tested in accordance with this specification herein and the service providers' standard procedures.
   1. Correct node and subnet configuration
   2. Proper usage of equipment i.e. switches, routers, hubs
   3. Node count

4. Repeater configuration and optical power loss for fiber circuits
5. Redundant network function
6. Utilization, errors, collisions, broadcasts, protocols, stations, device detection, and connectivity for components shown on the network block and connection diagrams
7. Proper network and equipment safety grounding

3.04 NETWORK CONFIGURATION VALIDATION REPORT

A. Provide written verification results and recommendations.
   1. Operation of communication ports results
   2. Data communication circuit from end-to-end for each link of the network results
   3. Validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain, results
   4. Validation of snooping within each domain, results
   5. Network performance results

END OF SECTION

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SECTION 40 66 13

SWITCHES AND ROUTERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the switches and routers required to provide the network configuration as specified in the project documentation.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
EIA	Electronics Industries Alliance
TIA	Telecommunications Industry Association
NEC	National Electrical Code
NESC	National Electrical Safety Code

1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01 33 00. The submittal shall contain a cover sheet, indexed by item, and cross-referenced to the appropriate specification paragraph, and be organized in the following order:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
3. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
4. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
5. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
6. A copy of Specification Sections 01 11 80 and 01 73 23, with addendum updates included, with each paragraph check-marked to indicate specification compliance. Failure to a copy of the marked-up specification sections shall be cause for rejection of the entire submittal with no further review.

1.04 PROJECT / SITE CONDITIONS

A. The equipment shall be designed and manufactured to meet the specified requirements of Section 01 11 80 and 01 73 23 for environmental and seismic conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND SERVICE PROVIDERS

A. Candidate manufacturers and service providers include:
   1. Cisco
   2. Phoenix Contact
   3. Or approved equal

2.02 PRODUCT DATA

A. Applicable information shall be provided in the product submittal, including:
   1. Test Equipment calibration certification for any testing devices used.
   2. Network block diagram and network routing site plan drawings.
   3. Testing Services Report sealed by a Registered Electrical or Control System Engineer.

B. Industrial Ethernet Fiber Optic Transceiver: Network fiber optic to ethernet transceiver to provide connectivity between the control system network components. The transceiver shall be used as shown on the System Architecture drawing. Provide the switch with the following minimum features:
   1. Steel industrial-strength enclosure
   2. DIN-rail mounted
   3. (1) RJ-45 connector

4. 100 Mbps operation (100Base TX)
5. Owner-approved fiber optic connectors
6. Phoenix Contact FO converter FL MC 2000 series, or approved equal

C. DIN-rail Mounted Ethernet Switch
1. Fully Managed, Layer 3 ethernet switch
2. 10/100/1000 Mbps ethernet
3. 2 x SFP ports
4. 6 RJ-45 ports
5. Cisco IE3100 Series, Phoenix Contact FL Switch 2200 series, or approved equal

D. Rack-mounted Ethernet Switch
1. Fully Managed, Layer 3 ethernet switch
2. 10/100/1000 Mbps ethernet
3. 4 x SFP ports
4. Minimum 24 RJ-45 ports
5. PoE support, with power supply
6. Cisco IE9320 Series, or approved equal

PART 3 EXECUTION

2.03 ONSITE NETWORK INSPECTION AND VALIDATION SERVICES:

A. Coordinate the network inspection, validation and testing services with the Construction Manager.

2.04 FIELD TESTING

A. The network equipment shall be tested in accordance with Section 40 66 00 and service provider's standard procedures.
1. Test operation of communication ports.
2. Test data communication circuit from end-to-end for each link of the network.
3. Test for validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain.
4. Test for validation of snooping within each domain.
5. Test the performance of the network.
6. Test segment attenuation against segment propagation delay calculation.

2.05 FIELD VERIFICATION

A. The network equipment shall be tested in accordance with Section 40 66 00 herein and the service providers' standard procedures.
1. Correct node and subnet configuration.
2. Proper usage of equipment i.e. switches, routers, hubs.
3. Node count.
4. Repeater configuration and optical power loss for fiber circuits.

5. Redundant network function.
6. Utilization, errors, collisions, broadcasts, protocols, stations, device detection, and connectivity for components shown on the network block and connection diagrams.
7. Proper network and equipment safety grounding.

2.06 NETWORK CONFIGURATION VALIDATION REPORT

A. Provide written verification results and recommendations.
   1. Operation of communication ports results.
   2. Data communication circuit from end-to-end for each link of the network results.
   3. Validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain, results.
   4. Validation of snooping within each domain, results.
   5. Network performance results.

END OF SECTION

SECTION 40 66 33

METALLIC AND FIBER-OPTIC COMMUNICATION CABLING AND CONNECTORS

PART 1 GENERAL

1.01 SCOPE

A. Provide the fiber optic appurtenances required to complete the fiber optic cabling system as shown on the project documentation. Section 26 specifications address requirements for fiber optic data communication cables including installation, terminations, and testing.

1.02 QUALITY ASSURANCE

A. References:

1. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ICEA S-87-640	Standard for Optic Fiber Outside Plant Communications Cable.
TELCORDIA (BELLCORE) GR-20-CORE	Generic Requirements for Optical Fiber and Optical Fiber Cables
TELCORDIA (BELLCORE) GR-409-CORE	Generic Requirements for Intrabuilding Fiber Cable
TELCORDIA (BELLCORE) GR-487-CORE	Generic Requirements for Electronic Equipment Cabinets
TELCORDIA (BELLCORE) GR-771-CORE	Generic Requirements for Fiber Optic Splice Closures
ISO-9001	Quality Management Systems
NFPA 70	National Electric Code (NEC)
TIA/EIA-455-86	FOTP-86 Fiber Optic Cable Jacket Shrinkage
TIA/EIA-455-107A	FOTP-107 Determination of Component Reflectance or Link/System Return Loss Using a Loss Test Set
TIA/EIA-492AAAC	Detail Specification for 850 nm Laser-Optimized, 50µm Core Diameter/125 µm Cladding Diameter Class IA Graded-Index Multimode Optical Fibers
TIA/EIA-598-C	Standard for Optical Fiber Cable Color Coding

1.03 SUBMITTALS

A. The following information shall be submitted for review in accordance with Section 01 33 00:

1. Product Literature:
    a. Manufacturer's catalog literature and catalog data sheets for the following items, marked to indicate products proposed, as applicable to the project:
        1) Fiber optic patch cords

2) Fiber optic termination panels

b. Shop drawings:

1) Termination panel fabrication and layout drawings with complete list of materials and nameplate engraving list.

2) Interconnection cable diagrams for the complete system, showing each fiber and color in each cable. Each termination point shall be clearly marked.

PART 2 PRODUCTS

2.01 FIBER OPTIC CABLE PATCH CORDS

A. General:

1. Provide preparation for the connections including polishing, connectors, hardware, cleaving tool, continuity tester, visual fault locator, and supplies for installation of connectors. Terminations shall be LC type. Fusion-spliced pigtails are acceptable.
2. Fiber optic cable connections shall be provided with ceramic ferrules; polycarbonate ferrules are not acceptable.

B. Single Mode Patch Cord Characteristics:

1. Patch cords shall be OS2 duplex fiber with jacket and connectors on both ends. Attenuation shall be a maximum of 0.2 dB. Provide length required for connection from patch panel to equipment.

2.02 FIBER OPTIC PANELS

A. General:

1. Fiber optic patch panels shall consist of a system of components for routing, supporting, and terminating the fiber optic cables specified herein. Terminations shall be LC type. Fiber optic cable connections shall be provided with ceramic ferrules; polycarbonate ferrules are not acceptable.

B. Description:

1. Provide the following:
   a. Wall-mounted type fiber optic patch panels constructed of aluminum or steel with removable hinged doors.
   b. Provide mounting hardware, cable clamps and grommets, cable routers, storage decks, connector racks, and items for a complete system.
   c. Cable routers and storage decks to retain cables' minimum bending radius.
   d. Sufficient quantity of ports to terminate the number of fiber strands specified and blank covers for unused port spaces.
   e. One port for each fiber in accordance with the specified cable type.
   f. Panel shall be Corning Cable Systems Pretium PWH, or approved equal.

2.03 PRODUCT DATA

A. The following information and product data specified under individual specification sections shall be provided in accordance with Section 01 33 00.

1. Provide a manual which includes manufacturer's operation and maintenance information as specified in Section 01 78 23. Manual shall include final reviewed submittal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Patch panels and patch cords shall be installed in accordance with the manufacturer's instructions.

END OF SECTION

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SECTION 40 67 00

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies requirements for panels, enclosures, and control stations for instruments, control and communications per the Panel Schedule herein.
2. This section specifies requirements for power supply and conditioning equipment required to support the instrumentation and communication systems specified.
3. Provide the instrument, control, and monitoring features indicated on the P&ID and electrical drawings. Panels shall be arranged to separate control and instrument devices from power wiring. Panels shall be arranged for dedicated field wiring terminations rated for 600VAC or less for power, control, and instrument signal wiring, in accordance with NEC Article 409. Panels shall be fabricated by a UL 508A recognized facility and shall bear the appropriate UL 508A Industrial Control Panel label. Panels for hazardous (classified) locations shall bear the appropriate UL 698A label. Panels shall be labeled in accordance with Article 409 of the National Electrical Code.
4. Transmitters, analyzers, signal conditioning modules, and other equipment or devices as specified in other Division 40 sections.
5. Panels that contain programmable logic controllers (PLC) and operator interface terminals (OIT) units shall be as indicated in the Panel Schedule. Specific panel devices are specified herein and in Division 26 sections.
6. PLC and OIT shall comply with those specified in Division 40. Panels that do not comply with the specified products and specified logic method, hardwired or PLC logic, shall not be accepted. Cost to retrofit the panel as specified shall be borne by the panel supplier. Corrections or modifications to UL 508A Industrial Control Panels shall be transported to the panel supplier's facility for corrections, testing, relabeling and inspection.
7. Field modifications require a UL inspector site inspection for approval of panel corrections and to re-label the panel after the field modifications are completed.
8. Vendor and Manufacturer panels specification Sections are referenced in the Panel Schedule and specify specific requirement for these panel. Contractor custom panels are specified herein and shown on the drawings.
9. The vendor or manufacturer-supplied package equipment and Contractor custom field panels shall adhere to the requirements in specifications in Division 26 for motor starters, controllers, and devices and the circuits shall be arranged for fail-safe wiring and electrical operation, as defined hereinafter.

B. Panel Design:

1. General:
   a. Panel hardware and software is specified in other sections within Division 40.

2. Control Power Distribution:
    a. Panel containing 120VAC-powered equipment shall use the DIN-rail power distribution method with fuses and blown fuse indication. Power is restricted to 120VAC and 24VDC, unless otherwise noted.
3. Panels containing voltages greater than 480VAC shall be separated from the control section by a physical barrier(s).
4. Power Supplies:
    a. Panels containing direct current powered instruments or serving as the termination point for transmission loop powered field instruments shall contain direct current power supply systems as specified herein.
5. Electrical Control Devices:
    a. Pushbuttons, indicating lights, relays, and similar equipment located in panels specified in this section shall comply with the requirements in Division 26.
6. Uninterruptible Power Supplies (UPS):
    a. UPS 120VAC input and 120VAC output are specified herein.

C. Control Panel Schedule is in Attachment A

1.02 QUALITY ASSURANCE

A. References:
1. This section contains references to the following documents that are part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
3. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
EIA RS-310C	Racks, Panels, and Associated Equipment
NEMA 250	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508A	Industrial Control Panels
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations
NFPA 79	Electrical Standard for Industrial Machinery
NFPA 70	National Electrical Code (NEC)
NEMA ICS 6	Industrial Control and Systems: Enclosures

Reference	Title
ANSI/UL 497-1995	Standard for Protectors for Paired Conductor Communications Circuits
UL 1012	Power Supplies
EIA RS-310C	Racks, Panels, and Associated Equipment
UL 1449	UL Standard for Safety for Surge Protective Devices

4. This Section references other sections with associated work specified therein:
    a. Section 01 45 20 specifies Equipment and System Performance and Operational Testing with reference to Contractor's Quality Assurance Manager that is responsible for startup commissioning of systems including mechanical, HVAC, electrical, and instrumentation.
    b. Section 26 05 00
    c. Section 40 61 21
    d. Section 40 63 43
    e. Section 40 61 96

B. Listed Products:
    1. Equipment and components shall be UL listed for the purpose or UL recognized.
    2. The control panels shall have factory applied UL 508A labels. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL.
    3. All panels shall be labeled in accordance with NEC Article 409.

C. Factory Testing:
    1. Prior to shipment, the manufacturer shall test the functional operation of the control panel as described in Section 40 61 96.

D. Shipment, Protection and Storage:
    1. Equipment shipment, protection and storage shall conform to the requirements specified in Section 01 66 00.

1.03 SUBMITTALS

A. General:
    1. Submittals and transmittal procedures for submittals are defined in Section 01 33 00. Submit In accordance with the procedures set forth in the General Conditions of the Contract Documents and Section 01 33 00 that include drawings, information and technical data for equipment and as required in Section 40 61 13.01. Submittal information shall be included in one complete submittal.
        a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
            1) A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

2) The Owner's Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

3) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

b. A copy of the contract document process and instrumentation diagrams (P&ID) relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

c. Marked contract document control schematic diagrams related to the submitted equipment.

d. Marked contract document control single line diagrams related to the submitted equipment.

e. Marked product literature of all the enclosure electrical devices and components mounted on or within the control panel.

f. List of miscellaneous items, cables, spare and replenishment parts, and chemicals to be provided, including MSDS information.

g. Dimensioned drawings:
   1) Exterior panel and layout
   2) Interior devices and layout
   3) Door-in-door construction devices, where required

h. Panel assembly drawings including sections showing clearances between face and rear mounted equipment.

i. Nameplate engraving schedule:
   1) Indicate engraving by line
   2) Character size
   3) Nameplate size
   4) Panel and equipment tag number and description

j. Heat load calculations for each cabinet based on the highest ambient temperature listed in Section 40 61 13 for the area in which the subject panel will be located.

k. Wiring drawings:
   1) Schematic diagrams
   2) internal wiring diagrams
   3) Connection diagrams
   4) Power and control single line diagrams to comply with NEC Article 409.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 40 61 13

PART 2 PRODUCTS

2.01 FABRICATION

A. General:

1. Panels shall be designed for the seismic requirements of the project specifications. Structures, equipment, and devices shall be braced to prevent damage from specified forces. Equipment panels shall be capable of operation following a disturbance.
2. Nameplates with tag number and equipment description shall identify face-mounted instruments. Instruments shall be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers. Instrument tag numbers shall be identified on the panel rear.
3. Face-mounted equipment shall be flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6" deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1" x 1/8" thick steel angle.
4. Panels less than 60" high shall be provided with floor stands to raise the top of the panel to 60" above the floor or work platform. Panels that weigh less than 100 pounds may be wall mounted.
5. Panels with specified requirements including stainless steel or aluminum mounting requirements that are indicated on the project drawings or on the project details take precedence over the panel types or panel features indicated herein.

B. Panel Layout:

1. Provide 20% spare contiguous sub-panel area for future expansion
2. Provide minimum of 20% spare terminal blocks, with a minimum of 10 analog, discrete, and power
3. Separation between the power components (>120VAC) and the control / instrument components (≤120VAC) by locating the power components and the control/instrument components in separate sections of the cabinet enclosure
4. Power cabinet section and the control/instrument cabinet section with separate door handles
5. Separation between the power components and the control/instrument components using barriers
6. External lockable circuit breaker handle for the main panel disconnect
7. Individual power and control components with internal circuit breakers, as required
8. Motor controllers, as required by the equipment specifications
9. Displays with door-in-door construction accessible by opening the cabinet outer door
10. Face-mounted equipment flush or semi-flush with flat-black escutcheons
11. Panel tops of wall-mounted panels: mounted at the same elevation
12. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409
13. Panel inner door contains a drawing holder
14. Panel drawings enclosed in a transparent, protective jacket
15. Panel functions as specified

16. Panels with floor stands, to raise the top of the panel to 60” above the floor or work platform
17. Wall mounting of panel weighs less than 100 pounds, where wall space is available,

C. Enclosures:
   1. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250
   2. Manufacturer:
      a. nVent Hoffmann
      b. Rittal
      c. Or approved equal

2.02 ENVIRONMENTAL CONTROL

A. Environmental controls shall be provided as required to maintain the environmental ratings of the enclosed components and shall maintain the NEMA enclosure rating as required by its location.

B. Heating: Panels located in unconditioned areas or outdoors shall be provided with thermostatically-controlled space heaters as required to maintain the panel temperature 10°F above ambient to prevent condensation within the panel. Space heaters with surface temperatures that exceed 120°F require an expanded metal guard. Thermostats shall be Honeywell T631 series, Johnson Controls A28AA-4, or approved equal.

C. Ventilation: Fans shall be equipped with UL-approved washable filters and provide at least 240 cubic feet per minute (CFM). Fans shall be thermostatically controlled. Noise level at 3’ from exterior wall and 30° off axis shall not exceed 60 NC units.

D. Air Conditioning: Systems shall not exchange cabinet interior air with ambient air.
   1. The cooling system shall be either a closed glycol loop heat exchange system or a CFC-free refrigeration system as required for heat load and ambient temperature conditions.
   2. Panel air conditioner coils shall be Heresite, or approved equal, coated and protected from corrosion.

2.03 PROTECTION COATING AND FINISH

A. Panels located outdoors or located in corrosive areas shall be bottom coated with waterproof coatings.

2.04 NAMEPLATES

A. External door-mounted components and the panel description shall be identified with plastic nameplates. Machine-embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

B. The machine engraved laminated nameplates, composed of white phenolic stock with black lettering, shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32" minimum size lettering.

C. The machine-embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

D. The nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws. Provide RTV sealant for nameplates for NEMA 4X stainless steel panels.

E. The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal.

2.05 PANEL FEATURES

A. Interconnection Wiring: Panel Interconnecting Wiring:
   1. Panel control wiring: Single conductor stranded copper NEC rated Type MTW 16 AWG minimum (rated 10A per NFPA 79, Table 12.5.1), with an exception for factory supplied PLC wiring harnesses that are UL approved
   2. Panel instrument wiring: Twisted 16 AWG shielded pair or tri conductors
   3. Panel power wiring: Conductors specified in Division 26 and meet the NEC requirements for power including phase, grounded, and grounding conductors
   4. Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame retardant plastic wiring channels.
   5. Wiring channels shall comply with UL 94, Type V.
   6. Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50% maximum fill.
   7. Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.

B. Conductor Identification:
   1. Wiring shall be tagged at every termination with machine printed plastic sleeves or pre-printed self-sticking labels as manufactured by W.H. Brady, 3M, or approved equal. No hand-written labels are permitted.
   2. Three-part wire numbers for instrument and control panel internal conductors:
      a. Part 1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
      b. Part 2: Code letter and wire colors per the following tables
      c. Part 3: Number that identifies individual circuit conductor

Code	120VAC Conductor	Color
L	Power	Black
C	Control	Red
N	Neutral	White
PG	Ground	Green

Code	VDC Conductor	Color
PS	24VDC Power	Blue
PS	12VDC Power	Violet
S+	Signal (+)	Black
SG	Signal Ground	White
EG	Equipment Ground	Green
FV	Panel Foreign Voltage	Yellow

C. Conductor Installation and Protection:
   1. Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.
   2. Terminal blocks shall be strap screw type rated for 600V. Each terminal trip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8" high.
   3. No more than two connections shall be made to one terminal.
   4. Wire connectors shall be locking fork tongue or ring tongue insulated crimp type terminals.
   5. Terminal blocks shall be;
      a. Buchanan 0621-1
      b. Allen-Bradley 1492-HM1 600V 30A, finger-safe terminal block.
      c. Allen-Bradley 1492-CD3 600V 35A with #8 screw terminal block for ring or spade terminals.
      d. Phoenix Contact or Weidmuller, or approved equal

D. Field Wiring:
   1. Field wiring shall be connected to separate dedicated terminal blocks in a dedicated part of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.

E. Fuse And Fuse Holders:
   1. Fuses for 120VAC circuits shall have a minimum of 12,000A interrupting capacity and blown fuse indicators.
   2. Fuses for 24VDC circuits shall be fast acting glass tube type rated 1/8A or 1/10A for 4-20 mA loops.
   3. Fuses for 24VDC circuits shall be 1/2A for the power supply to individual instruments.
   4. Fuse holders shall be tip-out or draw-out type.
   5. Provide Phoenix Contact, or approved equal products.

F. Control Power:
   1. 120VAC control power source: Single power source for all control and DC power
      a. Provide control power transformers, as required for the load.
      b. Provide direct current power supplies, as required for the load.

c. Provide UPS for PLC and derived loop power as defined above, as required for the load.

G. Panel Power: Panel power source:
   1. Provide a 120VAC circuit for the panel equipment, as required.

H. Accessories:
   1. All panels with a PLC, OIT, or panel-mounted PC, shall include GFCI convenience receptacles and LED utility lights.
   2. Where included, receptacles and utility lights shall not be powered by the UPS.
   3. Print pocket
   4. Fold-up shelf of sufficient size, sufficient weight capacity, and the proper angle for supporting a laptop computer mounted to the exterior.
   5. External access port including GFCI 120VAC/15A duplex receptacle and RJ-45 network connection

I. Fail-Safe Wiring:
   1. Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.

2.06 ALARM AND TROUBLE DETECTION

A. The equipment control system shall incorporate a non-energized, open-state, output contact to activate on an alarm or trouble condition or on loss-of-power. Detection of a critical alarm or trouble condition shall cause the control system to initiate the shutdown or the operation of the equipment's controlled components to achieve a "Fail-Safe" condition.

B. Devices that signal an alarm or a trouble conditions shall latch in the alarm position and require a manual reset at the equipment control panel.

C. Alarm and trouble output shall:
   1. Open an output dry-contact
   2. Remain open until manually reset
   3. Not indicate abnormal condition when the equipment shutdown manually or automatically
   4. Indicate the alarm at the equipment control panel

D. Fail-Safe Design and Operation:
   1. Failure of part of a system shall not result in the failure of the rest of the system
   2. Failure of equipment or process shall not propagate beyond the failing device or equipment component
   3. Control design and operation shall prevent improper system functioning due to a circuit malfunction or operator error
   4. Control system design shall cause the controlled equipment to operate in a safe mode in the event of loss-of-power or the failure of a control system component.

2.07 CONTROL DEVICES

A. Control devices shall comply with Division 26.

2.08 INDICATING PILOTS

A. Indicating pilots shall be equipped with colored lenses as specified in Division 26.

2.09 POWER SUPPLY AND CONDITIONING EQUIPMENT

A. Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application.

B. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems.

C. DC power supplies:
   1. Redundancy step-diode isolation shall be provided for redundant DC power supply units and the power supply negative output terminal shall be grounded. Redundancy unit shall be Phoenix Contact, Model STEP-DIODE/5-24DC/2X5/1X10, or approved equal.
   2. Nominal 24VDC instrumentation and control power supply:
      a. Convection-cooled linear type or switching type
      b. Line regulation: 0.4% for line variations from 105V to 132V
      c. Load regulation: 0.4% for load variations from 0 to full load
      d. Ripple and noise: Not exceed 100mV peak-to-peak
      e. Hold-up time at maximum load: Not less than 16 milliseconds
      f. Continuous duty from 0 to 50ºC at rated load
      g. Output electronically current limited
      h. Over-voltage crowbar shutdown
      i. Output voltage:
         1) Rated 28VDC
         2) Adjustable ±5%
         3) Set to provide 26.4V to the panel direct current bus
      j. Power Supply: TDK-Lambda, or approved equal.
      k. Provide dry contact for failure alarm. Dry contact to be wired as an input to the nearest PLC.

D. Uninterruptible Power System (UPS):
   1. The UPS shall be on-line, computer-grade, double conversion type, with electrical isolation including output neutral. UPS shall be in a tower format and placed in the floor of the enclosure.
      a. Nominal input voltage: 120VAC
      b. Nominal output voltage: 120VAC

2. The online UPS system shall be provided with integral sealed no maintenance batteries, sized to provide full capacity backup power for 30 minute minimum at connected load with integral battery charger.
3. The panel supplier shall calculate the required kVA rating at 150% of connected load. Submit load calculations, schematic diagrams, and wiring connection diagrams. Provide battery cabling and other required cabling for a complete system.
4. The UPS shall provide space for wire entry and passage.
5. [The UPS shall be configured with a maintenance bypass switch to allow ease of removal from the panel and allow the panel to operate on utility power.
6. Uninterruptible power supply systems shall be as manufactured by Best Power Technology, Inc.; American Power Conversion; or approved equal.

2.10 SURGE PROTECTION

A. General: Surge protection shall be provided to protect the electronic instrumentation systems from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, be maintenance free, and self restoring.
   1. Provide lightning and surge protection devices at all antennas, as well as signal lines, communication networks, and power feeds for all lines that originate or are routed outside a building on any part of the existing or proposed circuits.
   2. Lightning and surge protection devices shall provide full protection from line to line and from line to ground. Units shall be DIN-rail mounted, rated for a minimum of 10kA maximum surge current and voltage suitable for the type of circuit being protected. Reaction time shall be on the order of nanoseconds.

B. Surge protectors shall be removable without changing the impedance of the circuit. Surge protectors product manufactures shall be:
   1. AC power lines shall comply with all requirements of UL 1449 3rd edition with listed devices having a minimum 18kA surge protection and RFI filtering.
      a. MTL MA30
      b. Joslyn Model 1663-08
      c. Taylor 1020FA
      d. Phoenix Contact
      e. Telematic
      f. Edco
      g. Liebert
      h. Powerware
      i. Or approved equal.
   2. For analog signal lines use ANSI/UL497 listed device with minimum 15kA protection SD Series, as manufactured by MTL, or approved equal.
   3. For Ethernet BaseT communications use UL 497A & UL 497B listed ZoneBarrier Model ZB24540IE, Category 6 Universal LAN Protector as manufactured by MTL, or approved equal.

2.11 PANEL GROUNDING

A. Each panel shall be provided with two copper ground bars.
   1. One bar (NEC required) shall be bonded to the panel or panel frame or back-plate and to the facility grounding system.
   2. Second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the panel ground bar only at one point.

B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.

C. Field analog wiring shields shall only be grounded at the signal ground bar. Test to verify that single ground point at panel signal ground bar.

D. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.

E. Ground bars for panels exceeding 36" width shall be ¼" x by 1" copper bars extending the entire length of the panel interior at the bottom of the panel.

2.12 PANEL DRAWING PROTECTION

A. Provide wiring diagrams in accordance with Section 01 33 00. Provide a panel-wiring diagram and schematic for each panel in a plastic bag or plastic container to avoid water damage and aging.

2.13 SPARE PARTS

A. The following spare parts shall be provided per panel:
   1. Five each of each type of pilot used in the panels
   2. Five each of each type and rating of fuse used in the panels
   3. Five each of each type primary protector surge suppressor used in the panels
   4. Two each of each type of surge protective device used in the panels

2.14 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's operation and maintenance information as specified in Section 01 78 23. Manual shall include final reviewed submittal and separate record of all final configuration, jumper, and switch settings.
   2. Test results as specified in Section 40 61 21.
   3. Manufacturer's certification for the performance of features of the specified equipment that cannot be readily inspected.
   4. Special requirements for delivery of the information such as time, manner, place, or quantity.
   5. Installation and training forms specified in Part 3.

PART 3 EXECUTION

3.01 GENERAL

A. Floor-mounted cabinets shall be mounted and shimmed to precise alignment so doors operate without binding. Sealant shall be provided for conduit entering the panels.

B. Floor-mounted panels except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2" minimum height concrete pads or grouted bases as specified. Coating shall be provided for outdoor panels in contact on concrete.

C. For panels located in unconditioned areas, terminals and terminal blocks shall be sprayed after all terminations have been completed with a silicone resin conformal coating, Fine-L-Coat Type SR, Dow Corning, or approved equal.

D. Provide panels with the record as-built schematic, connection, and interconnection diagrams mounted behind plexiglass holder on the inside of the door. Place documentation in a waterproof clear bag in the panel document holder.

E. Verify that all panels have been labeled with Arc Flash warning labels per NEC 110.16. Provide labels, with Arc Flash protection boundary and PPE levels, in accordance with Division 26 specifications.

3.02 MOUNTING

A. Control panels supported directly by concrete or concrete block walls shall be spaced out not less than 5/8" by framing channel between instrument and wall. Sills shall be leveled so panel structures will not be distorted.

B. Support systems shall not be attached to handrails, process piping or mechanical equipment. Control panels supported directly by concrete or concrete block walls shall be spaced out from the wall to provide for air circulation around the panels.

C. Steel used for support of equipment shall be 316 stainless steel. Support systems including panels shall be designed to prevent deformation greater than 1/8" under the attached equipment load and an external load of 200 pounds in any direction.

D. Floor-mounted cabinets, except in dry control rooms or electrical equipment rooms, shall be mounted on 3-1/2" minimum height concrete pads or grouted bases as specified.

E. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.

F. Center-line of wall-mounted panels shall be 48" above the floor.

G. Panel tops of wall-mounted panels shall be mounted at the same elevation.

H. Panels shall be shimmed to precise alignment so doors operate without binding and mounted where shock or vibration will impair its operation.

3.03 OUTDOOR PANEL SHADE COVERS

A. Fabricate the custom aluminum panel shade cover and mount the panels facing away from the prevailing sun or wind.

B. Where called out, Contractor shall provide sun/rain covers per Electrical Detail for outdoor vendor, manufacture, and custom panels. Covers shall be fabricated based upon known panel dimensions or accepted submittal drawing dimensions.

3.04 PANEL POWER SUPPLY

A. Power supply and conditioning equipment shall be mounted and connected in compliance with the manufacturer's instructions.

B. Line side disconnect switches shall be provided for power supply and conditioning equipment. Line and load side overcurrent protection shall be provided for power supply and conditioning equipment in compliance with NFPA 70. Disconnect switches shall comply with Division 26 specifications.

C. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.

D. Power supply and conditioning equipment larger than 5kVA load capacity supported from surfaces other than concrete shall be provided with sound isolators.

E. Final raceway connections shall be a flexible conduit in compliance with Division 26.

3.05 FACTORY TESTING

A. The control panel shall be assembled, interconnected, and functionally tested at the assembly shop prior to shipment. The Owner/Engineer shall have the option of witnessing the functional shop test. The Contractor shall notify the Owner/Engineer at least 2 weeks in advance prior of the scheduled functional shop test.

3.06 FIELD TESTING

A. Field verify the following for Instrument and Control Panels:
   1. Control circuits grounded with one terminal of each load device connected to the grounded conductor.
   2. Control contacts installed in the ungrounded side of the circuit
   3. Panel signal and control wiring separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring
   4. Barriers between the power wiring and the signal and control wiring
   5. Connected to the plant grounding system, as specified
   6. Panel functions as specified
   7. Mounted with stainless steel unistrut, fittings, and fasteners

END OF SECTION

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ATTACHMENT A

CONTROL PANEL SCHEDULE

Process Control System Panel Schedule

Item	Area		Loop Number	Tag	Nameplate First Line	Nameplate Second Line	Nameplate Third Line	Nameplate Fourth Line	Specification	NEMA Rating	Panel Layout Drawing	Panel Wiring Diagram	Location Drawing	Application Notes
	35			35-PLC-9000	TREATMENT BUILDING PLC ENCLOSURE				40 67 00	12	GI-06	GI-07		not on electrical dwgs.
	70			70-PLC-9000	CLEARWELL PLC ENCLOSURE				40 67 00	4X	GI-06	GI-07		not on electrical dwgs.
	35			35-PLC-9001	FILTER 1 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	35			35-PLC-9002	FILTER 2 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	35			35-PLC-9003	FILTER 3 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	35			35-PLC-9004	FILTER 4 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	35			35-PLC-9005	FILTER 5 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	35			35-PLC-9006	FILTER 6 PLC ENCLOSURE				40 67 00	4X	GI-08	GI-09		not on electrical dwgs.
	01			01-LCP-00015	INFILTRATION GALLERY PUMPS	LOCAL CONTROL PANEL			40 67 00	4X				
	03			89-LCS-00010	SODIUM HYPOCHLORITE TRANSFER PUMP	LOCAL CONTROL STATION			40 67 00	4X				
	03			89-LCS-00020	SODIUM HYPOCHLORITE RECIRC PUMP 1	LOCAL CONTROL STATION			40 67 00	4X				
	03			89-LCS-00030	SODIUM HYPOCHLORITE RECIRC PUMP 2	LOCAL CONTROL STATION			40 67 00	4X				
	03			89-LCS-00040	SODIUM HYPOCHLORITE RECIRC PUMP 3	LOCAL CONTROL STATION			40 67 00	4X				
	03			89-LCS-00050	SODIUM HYPOCHLORITE RECIRC PUMP 4	LOCAL CONTROL STATION			40 67 00	4X				
	35			35-LCS-00010	RAW WATER SAMPLE PUMP	LOCAL CONTROL STATION			40 67 00	4X				not on electrical dwgs.
	35			35-LCP-10010	FLASH MIX PUMP 1	LOCAL CONTROL PANEL			40 67 00	4X				not on electrical dwgs.
	35			35-LCP-20010	FLASH MIX PUMP 2	LOCAL CONTROL PANEL			40 67 00	4X				not on electrical dwgs.
	35			35-LCS-00020	COAGULATED WATER SAMPLE PUMP	LOCAL CONTROL STATION			40 67 00	4X				not on electrical dwgs.
	35			35-LCP-00023	RAW WATER SAMPLE PANEL	LOCAL SAMPLE PANEL			40 67 00	4X				Vendor supplied
	30			30-LCP-11010	BASIN 1/STAGE 1 FLOCCULATOR 1A	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-11020	BASIN 1/STAGE 1 FLOCCULATOR 1B	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-12010	BASIN 1/STAGE 2 FLOCCULATOR 2A	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-12020	BASIN 1/STAGE 2 FLOCCULATOR 2B	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-13010	BASIN 1/STAGE 3 FLOCCULATOR 3A	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-13020	BASIN 1/STAGE 3 FLOCCULATOR 3B	LOCAL CONTROL PANEL			40 67 00	4X				
	30			30-LCP-21010	BASIN 2/STAGE 1 FLOCCULATOR 1A	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	30			30-LCP-21020	BASIN 2/STAGE 1 FLOCCULATOR 1B	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	30			30-LCP-22010	BASIN 2/STAGE 2 FLOCCULATOR 2A	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	30			30-LCP-22020	BASIN 2/STAGE 2 FLOCCULATOR 2B	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	30			30-LCP-23010	BASIN 2/STAGE 3 FLOCCULATOR 3A	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	30			30-LCP-23020	BASIN 2/STAGE 3 FLOCCULATOR 3B	LOCAL CONTROL PANEL			40 67 00	4X				On Electrical Drawing but couldn't find on the P&IDs?
	40			40-VCP-10010	SOLIDS COLLECTOR 1A	VENDOR CONTROL PANEL				4X				
	40			40-VCP-10020	SOLIDS COLLECTOR 1B	VENDOR CONTROL PANEL				4X				
	40			40-VCP-20010	SOLIDS COLLECTOR 2A	VENDOR CONTROL PANEL				4X				
	40			40-VCP-20020	SOLIDS COLLECTOR 2B	VENDOR CONTROL PANEL				4X				
	35			35-LCS-00110	COMBINED FILTERED WATER SAMPLE PUMP	LOCAL CONTROL STATION			40 67 00	4X				not on electrical dwgs.
	70			70-LCS-00010	SCOUR BLOWER 1	LOCAL CONTROL STATION				4X				
	70			70-VMP-0010	SCOUR BLOWER 1	VENDOR MONITORING PANEL				4X				
	70			70-LCS-00020	SCOUR BLOWER 2	LOCAL CONTROL STATION				4X				
	70			70-VMP-0020	SCOUR BLOWER 2	VENDOR MONITORING PANEL				4X				
	84			84-LCS-00010	PEA TRANSFER PUMP	LOCAL CONTROL STATION				4X				
	84			84-VCP-10010	POLYMER BLENDING UNIT 1	VENDOR CONTROL PANEL				4X				
	84			84-VCP-20010	POLYMER BLENDING UNIT 2	VENDOR CONTROL PANEL				4X				
	35			35-LCS-00050	TREATMENT BLDG RECYCLE PUMPS 1 & 2	LOCAL CONTROL STATION				4X				not on electrical dwgs.
	35			35-LCS-00100	TREATMENT BLDG DRAINAGE PUMPS 1 & 2	LOCAL CONTROL STATION				4X				not on electrical dwgs.
	70			70-LCS-00010	TREATED WATER SAMPLE PUMP	LOCAL CONTROL STATION				4X				
	73			73-LCS-00010	PLANT WATER PUMP 1	LOCAL CONTROL PANEL				4X				not on electrical dwgs.
	73			73-LCS-00020	PLANT WATER PUMP 2	LOCAL CONTROL PANEL				4X				not on electrical dwgs.
	71			71-LCS-00010	BACKWASH SUPPLY PUMP 1	LOCAL CONTROL PANEL				4X				not on electrical dwgs.
	71			71-LCS-00020	BACKWASH SUPPLY PUMP 2	LOCAL CONTROL PANEL				4X				not on electrical dwgs.
	71			71-LCS-00030	BACKWASH SUPPLY PUMP 3	LOCAL CONTROL PANEL				4X				
	70			70-LCS-00020	STRUCTURAL UNDERDRAIN PUMPS 1 & 2	LOCAL CONTROL STATION				4X				70-LCS-00040 On electrical drawing?
	60			60-LCS-00013	WASTE BACKWASH WATER CLARIFIER	LOCAL CONTROL STATION				4X				
	60			60-LCS-00010	RECYCLE PUMPS	LOCAL CONTROL STATION				4X				
	70			70-LCS-00060	CARRIER WATER PUMP 1	LOCAL CONTROL STATION				4X				
	70			70-LCS-00070	CARRIER WATER PUMP 2	LOCAL CONTROL STATION				4X				

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SECTION 40 68 00

PROCESS CONTROL SOFTWARE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies the general requirements applicable to the development and programming of the process control system graphical operator interface, historical data management system, and process control logic.
   2. The services described in this specification will be provided by the owner and are NOT included in the Contractors Scope of Work. This specification is provided to the Contractor for information only.

1.02 QUALITY ASSURANCE

A. Implementation Plan Meetings:
   1. The Systems Integrator shall include as work of this section of the specifications the requirement for 2 meetings to be held at the project site. The primary function of the meetings shall be to solicit input from the Owner regarding the implementation of the process control system and to facilitate preparation of the Process Control System Implementation Plan specified herein.
   2. The Systems Integrator shall have in attendance at each meeting a representative who is responsible for the preparation of the Process Control System Implementation Plan. The preliminary schedule and agenda for each of the meetings shall be as described below. The specific dates for each of the meetings shall be scheduled by the Systems Integrator and approved by the Construction Manager.
   3. The Construction Manager shall be provided with 2 weeks minimum advanced written notice of proposed scheduled meeting dates. The System Integrator shall prepare a detailed meeting agenda and submit it to the Construction Manager with the notice of proposed scheduled meeting dates.
      a. Meeting 1 shall be held within 60 days of receipt of Notice to Proceed. The purpose of this meeting shall be to begin preparation of the Process Control System Implementation Plan. The System Integrator shall be prepared to present the capabilities of the proposed process control system software and the alternatives available for each of the major areas of implementation described by the Process Control System Implementation Plan.
      b. Meeting 2 shall be held within 30 days of completion of the Engineer's review of the Process Control System Implementation Plan submittal. The purpose of this meeting shall be to discuss the submittal review comments and resolve any related issues.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Process Control System Implementation Plan

PART 2 PRODUCTS

2.01 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Process Control System Developer's Guidelines: The Process Control System Implementation Plan shall be modified and updated during the course of development of the process control system control logic and graphical operator interface to reflect the conventions and standards used in the final system development. Upon final acceptance of the work, the updated implementation plan shall be re-published and submitted as the Process Control System Developer's Guidelines.
   2. Process Control System Configuration Report:
      a. Report documenting the final configuration of the process control system including the following:
         1) Hardware Configuration: Final switch settings and jumper positions shall be documented for all process control system components including processors, communications adapter modules, motor controllers and adjustable frequency drives, power metering systems, etc.
         2) Process Control Logic: Bound hard copy of the annotated process controller program listing. The program listing for each processor shall be separately bound and shall have tab dividers for each program file listing. Program listing shall include cross references.

PART 3 EXECUTION

3.01 PROCESS CONTROL SYSTEM IMPLEMENTATION PLAN

A. General:
   1. The Systems Integrator shall prepare an implementation plan for the process control system development and programming work. The implementation plan shall establish guidelines for development of the graphical operator interface, the historical data management system and the PLC process control logic and shall insure the consistent application of conventions and methods through the course of development. The implementation plan shall specifically address the following:
      a. Tag database structure and configuration
      b. Tag naming conventions
      c. Graphical operator interface standards
      d. Process control system configuration
      e. PLC program file organization
      f. PLC data file organization
      g. List and description of graphic displays

B. Tag Database Structure and Configuration:
   1. The implementation plan shall define how the tag database will be organized to logically associate tags with specific input/output types, functions, or process areas. In addition, the plan shall prescribe guidelines for configuration of tag alarm handling and annunciation and tag data logging.

C. Tag Naming Conventions:
   1. A tag naming convention shall be established which provides a structured organization to the tag database facilitating tag searches and substitutions during system development and provide for effective and efficient design, management and operation of the process control system. The tag naming convention shall be developed to take full advantage of the capabilities of the process control system software and not impose any artificial constraints in the operation or management of the process control system. Tag names shall minimally be comprised of the following information:
      a. Equipment type designation
      b. Equipment loop number
      c. Signal type designation

D. Graphical Operator Interface Standards:
   1. The configuration and development of the graphical operator interface shall be based on standards prepared specifically for this application. The interface standards shall be consistently applied to the development of the interface to insure optimum usability.
   2. All HMI development including tag naming scheme, screen navigation methods, use of pop-ups, etc. shall be implemented in a manner that is consistent with HMI systems in use elsewhere in the Owner's existing operations at other facilities. Graphic screens shall utilize the same colors, symbols, fonts, and features to provide an interface to operators that is uniform and consistent with existing HMI screens serving Owner's other facilities.
   3. The interface standards shall specifically address the following topics:
      a. Graphical Display Type: The user interface will be comprised of various types of graphic displays including schematic overviews, control panels, faceplates, utility displays, and trend displays. The content and layout of each type of interface including navigational and utility features shall be defined by the standard. The standard shall also define the naming conventions for graphic display files.
      b. Symbology: The symbology used in the preparation of the graphical interface shall be defined by this standard. The symbology standard shall address the following symbol types:
         1) Symbols representing process equipment, structures, piping, and systems
         2) Navigational and utility system icons
         3) Dynamic data display objects including numeric displays, bar graphs, indicating lights, text labels, etc.
         4) Control objects including pushbuttons, selector switches, slider bars, setpoint entry, etc.
      c. Colors: The color standard shall define the foreground, background, and border colors used to indicate dynamic conditions (run, stop, alarm, trouble, ready, etc.), process-specific applications (raw water, settled water, finished water, chemicals, etc.), graphic display backgrounds, dynamic data objects, text, control objects, etc.
      d. Visibility: The visibility standard shall define the following:
         1) Application of blinking to graphic objects
         2) Application of font styles and sizes

3) Manipulation of graphic object color to represent different conditions

e. Terminology: All terminology used to annotate the graphical interface shall be defined by these standards. The terminology standards shall define the following:
   1) Descriptive names used to identify the treatment processes, systems, structures, equipment, process variables, etc.
   2) Units of measurement for all process variables
   3) Alarm condition descriptors
   4) Abbreviations

f. Navigation: The navigation standard shall define the organization of the user interface and the features of the navigational system. This standard shall address all techniques used to implement the navigation system and where and how the navigation system is accessed including button bars, shortcut icons, hot links, continuation labels, and graphic menus.

E. Process Control Logic Configuration:
   1. Guidelines shall be developed which define the organization and structure of the process control logic and data memory within the process controller. These guidelines shall address the following:
      a. Structure of the control logic including the use of subroutines and the allocation of memory to accommodate modifications and expansion of the control logic.
      b. Methodology for handling common control functions shall be standardized such that similar functions are implemented in a consistent manner across the entire project. Standardized routines for motor control, VFD control, instrument data handling, alarm management, etc., shall be developed and reviewed by the Owner prior to final programming.
      c. Assignment of data storage memory including data formats and method of documenting memory mapping.
      d. Methodology for implementing peer to peer communications including allocation of memory or register addresses is such a way as to organize data for optimum efficiency of data exchanges between peer processors.

F. Process Control Strategies:
   1. Process control strategies shall be reviewed with the Owner and refinements made as agreed to by the Systems Integrator. Modifications to the control strategies that are determined to be a change in scope will be addressed by change order. The final process control strategies shall be incorporated into the Implementation Plan.

3.02 TAG DATABASE DEVELOPMENT

A. General:
   1. The process control system tag database development shall include the definition of all device, derived and soft tags and the required alarm processing and data logging and archiving definitions for each tag. Conventions used in the development of the tag database shall be as defined in Process Control System Implementation Plan.

B. Tag Definition:

1. The definition of tags in the tag database shall comply with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    a. Tag Naming Conventions:
        1) Tag names shall minimally consist of two distinct components. The leading component shall represent the tag equipment number. The trailing component (tag descriptor) shall be an abbreviated description of the associated process variable or the function of the tag. Each component shall be assigned a fixed maximum length which shall be dependent on the available tag name length supported by the process control system software.
        2) The tag equipment number shall be derived from the primary item of process equipment or instrumentation most closely associated with the process variable and shall be comprised of an equipment type prefix followed by process loop number. The equipment numbers shall be as defined by the Contract Documents.
        3) The tag descriptor shall provide a description of the process variable referenced by the tag name or a description of the function associated with the tag. Tag descriptors shall be based on ANSI/ISA-S5.1 and Appendix B of ISA-RP60.6. The tag descriptor may be comprised of several parts to clearly define the tag function. The following typographical convention shall be used to create the tag descriptor:
            a) Symbol identification letters (ANSI/ISA-S5.1) shall be all upper case.
            b) The first letter of an abbreviation (ISA-RP60.6) shall be upper case. The remainder of the abbreviation shall be lower case.
        4) Examples of the tag names are provided in Table 3.02.B.1:

Table 3.02.B.1

Tag Name	Tag Function
P1121PSH	Pump P1121 pressure switch high
FIT1101	Flow transmitter 1101
P1121Run	Pump P1121 run status

2. Tag Descriptions:
    a. Describe the tag in terminology consistent with this application. Abbreviations and equipment numbers shall be not be used in the tag description without prior approval of the Owner. Tag descriptions shall not include any wording which implies the state or condition of the tag. For example, the tag description for P1121PSH shall read “Backwash Water Pump 1 Discharge Pressure” in lieu of “Backwash Water Pump 1 Discharge Pressure High.”
3. ON/OFF and Alarm State Labels:
    a. The ON/OFF and alarm state labels shall consist of words which describe the state of the tag. For digital tags, the logic TRUE state of the tag will generally be the state labeled.
        1) Examples of ON/OFF and alarm state labels include RUN, OFF, OPEN, CLOSED, READY, ALARM, NORMAL, HIGH, LOW, HIGH-HIGH, LOW-LOW, etc. Abbreviations shall not be used in ON/OFF or alarm state labels.

C. Tag Types:

1. Tags shall be classified as either device tags, derived tags or soft tags. Device tags shall be those tags which have a physical device as the data source. Derived tags are those tags whose value is calculated or otherwise derived from another tag. Derived tags have no data source address. Soft tags are those tags whose value is obtained from another process software application. Tags shall be defined for each of the following tag data sources:
    a. Physical input/output process variables derived from the process control input/output subsystems. Refer to the Input/Output Summary, Section 40 63 43.
    b. Control and status data derived from the process control logic required to fully implement the process control strategies specified in Section 40 61 96. This data shall include the following types of information:
        1) Operating setpoints
        2) Process operations setup and control parameters including start/stop, lead/lag, auto/manual, enable, etc.
        3) Operating status and fault data including ready, fail-to-run, etc.
        4) Timing/counting function data including preset and accumulated values
    c. Operating, fault and diagnostic data derived from the external systems, such as chlorine generator, metering pump systems, including the following:
        1) Process variable transmitters and analyzers
        2) Operating status of all system equipment including run and ready status
        3) Power parameters
        4) System trouble and alarm conditions
        5) Process control system diagnostic data
        6) System status, control and configuration parameters including lead/lag selection, operating setpoints, etc.
        7) Refer to the particular equipment specification section in Divisions 23, 41, 43, 44, or 46 for specific data to be produced, consumed and transmitted by external systems
    d. Operating data derived from electronic power metering systems including the following power parameters:
        1) Kilowatts
        2) Kilowatt-hours
        3) Kilowatt demand
        4) Kilovars
        5) Kilovolt-amperes
        6) Kilovolt-ampere-hours
        7) Kilovolt-ampere demand
        8) Power factor
        9) Line currents
        10) Voltage (phase-to-phase and phase-to-ground)
        11) Line frequency

e. Operating, fault and diagnostic data derived from solid-state adjustable frequency motor speed controllers including the following:
   1) Run status
   2) Drive fault
   3) Start/stop control
   4) Speed setpoint
   5) Running speed
   6) Running amps
f. Diagnostic data derived from the process control system controllers, I/O subsystems, and communications controllers including the following:
   1) Controller operating mode
   2) Controller performance (e.g. Scan time)
   3) Controller fault status and fault code
   4) Controller time and date values
   5) Controller network address
   6) I/O subsystem fault status
   7) I/O module channel health
   8) Communication controller fault status
g. Analytical, operating and diagnostic data derived from turbidity instruments including, but not limited to the following:
   1) Instrument operating mode
   2) Particle count in each of the particle size ranges configured.
   3) Instrument diagnostic or fault status and status code
   4) Instrument network address
   5) Communication link status or fault condition.
h. Table 3.02.C.8 specifies the types of derived process variables and the associated real-time process variable.

Table 3.02.C.8

Real-time Process Variable Type	Derived Process Variable	Description
Flow	Totalized Flow	Totalized flow process variable shall be defined for all flow process variables.
Level	Volume	A process variable representing tank volume shall be defined for all chemical and fuel storage tanks and shall be based on the real-time level process variable and the geometry of the storage tank.
Run Status	Accumulated Runtime	An accumulated runtime process variable shall be defined for all rotating equipment which has an associated run status tag defined in the tag database.

D. Data Logging:
   1. Tags representing the following types of process variables shall be defined in the tag database for data logging. This data shall support historical and real-time dynamic trending functions.
      a. Flow or chemical feed rate

b. Process pressure
c. Storage tank level or volume
d. All analytical instrument values including pH, turbidity, particle count, temperature, and chemical residual
e. Filter loss of head
f. Chemical storage weight
g. Power parameters representing line current, kilowatts, kilovars, kilovolt-amperes, and power factor.

E. Alarm Handling, Annunciation, And Logging:
1. All discrete tags representing alarm or trouble conditions shall be defined in the tag database to be processed as alarms. All analog tags shall have alarm thresholds defined in the tag database. The value of the alarm thresholds shall be defined by the Owner during the preparation of the Process Control System Implementation Plan.
2. The tag database shall be configured to implement alarm processing and annunciation as defined by the Process Control System Implementation Plan. Each tag's alarm definition shall prescribe whether the occurrence of the alarm condition is logged to journal, printed, or audibly annunciated or any combination thereof.

3.03 GRAPHICAL OPERATOR INTERFACE DEVELOPMENT

A. General:
1. The process control system graphical operator interface development shall include the preparation of the specified graphic displays in accordance with the Process Control System Implementation Plan and the requirements of this specification. The Systems Integrator shall prepare additional graphic displays as may be required to provide a comprehensive process and system management graphical operator interface.

B. Development Guidelines:
1. The graphical operator interface shall be developed in accordance with recognized usability practices to insure efficient and effective use of the process control system. The completed graphical operator interface shall adhere to the following three principles of usability:
a. Learnability: The graphical operator interface shall be easy to learn so that the user can quickly start being productive with the tools provided by the system.
b. Efficiency: The graphical operator interface shall be efficient to use, so that once the user has learned the system, a high level of productivity is possible.
c. Memorability: The graphical operator interface shall be easy to remember, so that the casual user is able to return to the system after some period of absence without the need to learn the interface over again.

2. Adherence to the stated principles of usability shall be achieved through consistent application of the following development standards defined herein and as defined in the Process Control System Implementation Plan.
    a. Graphic Design: The layout and organization of each graphic display shall be consistent among the graphic display types and shall adhere to the following standards:
        1) Position similar information and features of the graphical operator interface at the same location on each display
        2) Enclose groupings of associated data in a frame or box
        3) Color conventions shall be consistently applied throughout the graphical interface. Foreground colors shall be selected to provide contrast to the background color. Verify that all colors chosen can be viewed by the end-user.
        4) Text font sizes, colors and types shall be consistently applied throughout the graphical interface.

C. General Graphic Display Configuration:
    1. Graphic displays shall be configured as either full screen displays or pop-up displays. Each type of display configuration shall include the following features:
        a. Full Screen Display
            1) Full screen displays shall be maximized, occupying the full, usable area of the window.
            2) Controls to close or minimize the window shall be disabled.
            3) Window exit control shall be embedded in the graphic display's navigational controls.
            4) Full screen displays shall remain in the background when a pop-up display is called from navigational hot links within the full screen display.
            5) Navigational and utility button bars shall be provided.
        b. Pop-up Display
            1) Pop-up displays shall not occupy the full window and shall appear in the foreground when called from a full screen display.
            2) Pop-up displays shall appear at a user-defined location on the background display when called, but shall have the capability to be dragged to a different location on the screen.
            3) Pop-up displays shall not be resizable.
            4) Pop-up displays shall be provided with close control.

D. Graphic Display Types:
    1. Graphic displays shall be categorized as either schematic overview, control panel, faceplate, trend or utility.
        a. Schematic Overview: The schematic overview graphic display shall be presented as a process flow diagram and shall represent major process piping, major equipment, process variable data, and process alarm and status data.

b. Schematic overview displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) Numeric display objects shall be provided to indicate the instantaneous value of all analog process data associated with the process. In addition, dynamic fill shall be used to indicate analog process data representing level.
    2) Dynamic equipment symbols shall be provided to indicate run, off, and fault conditions for all major equipment associated with the process.
    3) An alarm summary object indicating only those alarms related to the associated process shall be provided at the bottom of the display.
    4) Continuation labels shall be provided to access associated schematic overview displays.
    5) Hot links shall be provided on equipment symbols to provide access to an associated control panel display or faceplate.
    6) Hot links shall be provided on numeric display objects to access associated trend displays.
    7) Navigational and utility button bars shall be provided.
    8) Schematic overview shall be a full screen display.
c. Control Panel: The control panel graphic display shall be presented as a virtual control panel providing a point of operator interface for control of a specific equipment item or system.
d. Control panel graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) Graphical control objects representing selector switches, pushbutton, slider bars, etc., shall be provided to initiate the appropriate control function.
    2) All pertinent operating status data associated with the equipment or system controlled by the panel shall be indicated.
    3) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
    4) Control panels shall be configured as pop-up graphic displays.
e. PID controller Faceplate (if used): The PID controller faceplate graphic display shall represent the appearance and functionality of a typical PID controller. The PID controller faceplate graphic display shall provide a point of operator interface for control of a specific process.
f. PID controller faceplate graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) Analog data shall be presented in numerical and bar graph format.
    2) PID operating status such as mode, high/low limiting, deadband in effect, etc., shall be indicated.
    3) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
    4) PID controller faceplates shall be configured as pop-up graphic displays.
g. Trend Display: The trend graphic display shall present a graphical trend object with the associated controls to adjust the time scale and scroll the time axis.

h. Trend graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) A pen legend shall be provided which associates the trend plot to a process variable description through the use of color.
    2) Y-axis shall be graduated and labeled in the appropriate engineering units.
    3) Controls shall be provided to adjust the time scale and to scroll the X-axis backwards and forwards.
    4) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
    5) Trend graphic displays shall be configured as pop-up graphic displays.

i. Utility Display: The utility graphic display shall present all pertinent data associated with an ancillary support system. The utility graphic display shall provide a point of operator interface for control, monitoring and management of the specified utility system.

j. Utility graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) Provide a schematic representation of the utility system where specified.
    2) Numeric display objects shall be provided to indicate the instantaneous value of all analog process data associated with the utility.
    3) Dynamic symbols or labels shall be provided to indicate current condition of the utility and its components.
    4) Graphical control objects representing selector switches, pushbutton, slider bars, etc., shall be provided to initiate the appropriate control function.
    5) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
    6) Control panels shall be configured as either full screen displays or pop-up graphic displays, as specified.

k. PLC System Status Display: The PLC system status graphic display shall present all pertinent data associated with the process PLC system itself. The PLC system status graphic display shall provide a diagnostic interface for troubleshooting, monitoring and management of the PLC system. No control is associated with the PLC system status graphic displays.

l. PLC system status graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
    1) Provide a schematic representation of the PLC system where specified.
    2) Provide detailed displays for each PLC processor showing the processor status, including diagnostic and fault codes. Display shall include communication status of Ethernet, I/O bus and any additional communication links associated with the processor.
    3) Status of all discrete I/O points shall be indicated by dynamic text or colored graphical object. Status and raw data value of all analog I/O points shall be indicated by dynamic text.
    4) Dynamic symbols or labels shall be provided to indicate current condition of the processor and its components.

5) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.

E. Navigation System:

1. The navigation system shall be configured to provide a logical, intuitive path through the graphical operator interface and also provide the flexibility to directly access graphic displays and system utilities. The graphical operator interface shall be generally organized by process area; however, shortcuts shall be provided to navigate beyond process boundaries.
2. The graphical operator interface shall incorporate features to accommodate mouse-oriented navigation throughout the process control system. Scrollable menus, button bars, embedded hotlinks and continuation labels shall be used to create a navigational system which provides ready-access to commonly used displays and utilities.
3. The navigation system shall be implemented in accordance with the following guidelines unless otherwise modified by the Process Control System Implementation Plan:
   a. Process Overview Graphic Display: A process overview display schematically representing the overall facility shall be function as the system startup display and "home base" for conventional system navigation. Embedded hot links shall be provided on this display to permit access to all other displays.
   b. Continuation Labels: Continuation labels shall be provided on all process schematic displays where a process line continues to another process area. These labels shall have embedded hot links to the process schematic display referenced by the label.
   c. Graphic Menu System: A graphic menu system shall be provided where the navigational control action can result in multiple options. A graphic menu display shall be configured as a pop-up display and shall provide short cuts to associated graphic displays.
   d. Short Cut Icons: Short cut icons shall be utilized to provide direct access to typical display types. Short cut icons shall be provided to represent schematic displays, control panels, trend displays, and PID controller faceplates. Short-cut icons shall typically be applied to pop-up displays such as graphic menus, control panels, faceplates, and trend displays.
   e. Hot Links: Hot links shall be embedded in each of the following types of display objects to provide access to an associated display or menu:

Table 3.03.E.5

Display Object	Hot Link
Equipment Symbol	Associated trend, PID controller faceplate, control panel or graphic menu display
Numeric Display	Associated trend display

3.04 PROCESS CONTROL LOGIC DEVELOPMENT

A. The process control system control logic development shall include the preparation of control logic required to implement the specified control strategies and support the specified operator interface functions.

B. Organization:
   1. The control logic shall be organized in a hierarchical structure which correlates to the actual process relationships. Individual control logic program files shall be prepared for each system or equipment item and shall be organized by process area. Data table files shall be similarly organized by process area. Data types shall be consistently applied throughout the control logic in accordance with the Process Control System Implementation Plan.
   2. The control logic and data table organization shall facilitate the addition of future control logic.

C. Documentation:
   1. All control logic shall be completely annotated down to and including the instruction level. Each rung or statement of control logic shall be provided with annotation specific to its function. Each program file shall have a title and a detailed description of the control strategy represented by the control logic. Terminology consistent with the Process Control System Implementation Plan shall be applied throughout.

D. Control Logic Implementation:
   1. The project control strategies outline the general control requirements of the treatment process and associated utility systems. In addition to the requirements of the control strategies, the following control features shall be implemented in the process control logic:
      a. Fail to operate: All automatically operated equipment shall be monitored for failure to respond to control requests from the process control system. Upon a call to start, stop, open, close, etc., a fail timer shall be initiated. If the appropriate equipment status signal (run, off, full open, full closed) is not reported back to the process control system within the time duration defined by the fail timer, an alarm shall be initiated through the process control system human machine interface (HMI).
      b. Time based control: Process control logic for all equipment and processes' controlled on the basis of time duration shall provide for operator access to the preset value of the time function through the HMI and report back to the HMI the instantaneous value of the time function associated value.
      c. PID Regulatory control: Every PID regulatory control function implemented in the process control logic shall be interfaced with the HMI to provide the following functions:
         1) Report to the HMI the instantaneous values of the process variable, setpoint, and control variable.
         2) Report to the HMI the current operating mode, high/low limiting in effect, deadband in effect, cascade mode in effect, etc.
         3) Provide operator control of the operating mode, setpoint value, and the control variable in manual mode.

4) PID tuning parameters shall be accessible via password protected screens. Supervisor level access is required for modification of tuning parameters.

d. Control Setup Control functions which are described in the control strategies as operator initiated or invoked through the process control system HMI shall be interfaced with the HMI to permit operator manipulation of that control function and to report back the current status of the control configuration. Functions of this type include manual start/stop, lead/lag selection, hand/off/automatic selection, enable, setpoint adjustment, etc.

e. Real Time Data Server Communication: Control logic shall be implemented to facilitate and optimize the communication of data between the process control system real-time data server and the process controllers. Control logic shall be implemented as required to make the specified real-time data available to the tag database. Control logic shall also be provided to support optimization of the communication between the process control system HMI real-time data server and the process controllers. Data of similar format (binary, integer, floating point, string, etc.) shall be grouped in data tables designated a communication buffer files. All tags defined in the tag database shall be addressed to the designated communication buffer files.

3.05 ON-LINE HELP

A. An on-line help system shall be developed to provide an on-line reference for the use of the process control interfaces and a description of the conventions used throughout the graphical operator interface. The on-line help utility shall be WinHelp or HTML-based and shall address the following topics:

1. Graphical conventions used in the operator interface including symbols, icons, colors, etc.
2. Graphical operator interface navigation system
3. Standard procedures for login/logoff, printing, etc.
4. Functional description of each control panel graphic display including a graphic image of the display and descriptions of each object on the display

B. Topics in the help system shall be dynamically-linked with other related topics through the use of hypertext-sensitive jumps and popups. All help pages shall be indexed with keywords to facilitate the use of the help utility. The on-line help utility shall include a table of contents, index and glossary.

C. The on-line help system shall be called from the utility button bar within the graphical operator interface.

3.06 HISTORICAL DATA MANAGEMENT SYSTEM

A. The historical data management system development shall include the preparation of extracts to enter the following real-time process variable types and associated attributes into the historical database.

Table 3.06

Process Variable Type	Sample Interval	Attribute			
		Total	Average	Maximum	Minimum
Flow	Hourly		X	X	X
	Daily	X			
Level	Daily		X	X	X
Power	Daily	X	X	X	X
Pressure	Daily		X	X	X
Equipment Run	Daily	X			
Water Quality Analysis	Hourly		X	X	X
	Daily				
Volume/Weight	Daily		X	X	X

3.07 TESTING AND COMMISSIONING

A. The graphical operator interface shall be tested and commissioned in accordance with Section 40 61 21.

END OF SECTION

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SECTION 40 68 03

PROCESS CONTROL SOFTWARE COORDINATION AND DOCUMENTATION

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for the Contractor and Programmer performance in programming the control systems, progress tracking, testing, and documenting the work using the control specifications in Division 40.

1.02 QUALITY ASSURANCE

A. Contractor's Programming Manager
   1. The Contractor shall appoint a software engineer or qualified specialist as Programming Manager to manage, coordinate, and supervise the Contractor's programming work.
   2. The Programming Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the programming and startup of similar electrical and instrumentation control systems. The quality assurance program shall include:
      a. Definition of process areas and systems, with programming executed on an area by area basis, based on the P&ID drawings
      b. Programming for each process area executed in sequential tasks
      c. Regularly updated programming status tracking
      d. Regularly updated separate programming documentation for each process system
      e. Regularly updated application program software media

B. Definitions
   1. Control System: Controllers and any associated Operator Interfaces
   2. Controller:
      a. Programmable Logic Controller (PLC)
      b. Remote Terminal Unit (RTU)
   3. Operator Interface:
      a. Operator Interface Terminal (OIT), entire plant
      b. Human Machine Interface (HMI), for equipment, equipment panel
   4. Process Area: Area comprised of one or more process systems
   5. Process system: Packaged equipment system or subsystem. Refer to P&ID drawings and associated panels in project documentation.
   6. Input and/or output (I/O) signals:
      a. Physically hard-wired
      b. Via network
      c. Digital communication via ethernet or serial network

7. Operating System/Application Manufacturer's software used to program:
    a. Controller
    b. OIT
    c. HMI
8. Application Software: OIT and/or computer software used to display the process and alarms, create reports, enable communications, dial-out alarms, or otherwise enhance OIT functionality
9. Application Programs: Programs created using programming software and/or application software for control and interface specific to this project

C. Project Labeling
    1. The items specifying project labeling herein shall include the following as a minimum: Owner's name, facility name, project name, project number, and "Specification 40 68 00".

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Sections 01 33 00 and 40 61 13.01:
    1. Qualification Submittal:
        a. Provide the following submittal in accordance with Section 01 33 00:
            1) Programming Manager Qualifications and resume
            2) Proposed process area and process system breakdowns
            3) Example programming status spreadsheet per programming documentation
            4) Example I/O interface summary per I/O interface summary
            5) Initial schedule of operational testing for each process area and system
            6) Proposed final application program software media type
    2. Definition Submittal:
        a. Provide the following submittal after review of the Qualification Submittal, in accordance with Section 01 33 00:
            1) A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from Specification requirements. A check mark shall denote full compliance with a paragraph as a whole.
                a) If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
                b) The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

c) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2) A marked copy of specification Section 40 61 21.

3) A marked copy of specification Section 01 45 20

4) A marked copy of specification Section 40 61 96

5) I/O interface summary

6) Programming status spreadsheets

7) Revised schedule of operational testing for each process area and system

3. Operating And Maintenance Information Submittal:
   a. Provide O&M information upon completion of testing and commissioning in accordance with Section 01 78 23.

PART 2 PRODUCTS

2.01 GENERAL

A. The Programming Manager shall provide application programs, documentation, records, and software media as specified in the following paragraphs.

2.02 PROGRAMMING DOCUMENTATION

A. Documentation Records
   1. The Programming Manager shall develop a records keeping system to document progress and completion for each task in each process area or system. The following shall be kept current and available for inspection on-site at all times in a location designated by the Construction Manager:
      a. Programming Manager's qualifications, project programming history
      b. List of names of project programmers, and normal and emergency contact telephone numbers
      c. Programming status spreadsheet with percentage complete on each programming sequence task
      d. Programming documentation volumes
      e. Application program media

B. Documentation Volumes
   1. The Contractor shall develop and maintain programming documentation for each process area in separate volumes. Each volume shall be kept current and available for inspection on-site at all times in a location designated by the Construction Manager. Each volume shall include the following as a minimum:
      a. Three-ring binder with front cover and spine labeled:
      b. “Programming Documentation for (applicable) Process Area/Process System”
      c. Table of Contents with same labeling as the volume cover with tabs for each section:
         1) Section 1 – Control Description
         2) Section 2 – I/O Interface Summary

3) Section 3 – Control Program
4) Section 4 – Graphics
5) Section 5 – Reports

C. Control Description
   1. Provide an updated control description outlining application program operation for each process area's system. Section 40 61 96 may be used as a basis. Provide details on operator interaction, manual and automatic mode operation, setpoints, graphic indications, trending, and reports.

D. I/O Interface Summary
   1. Provide I/O spreadsheets which are to include the following for each I/O point:
      a. Signal number/tag
      b. Annotation description that may be logically abbreviated and that is subject to approval
      c. Complete physical I/O channel designation and addressing or communication I/O register designation
      d. True/False status designations for digital I/O
      e. Process range; engineering units and any multipliers; and raw signal range count for analog I/O
      f. Signals: Fixed point and scaled at the Controller with minimum four significant implied digits of scaling, e.g.: 0 to 1400 at Controller for a pH range of 0 to 14 at Operator Interface.
      g. Provide OIT scaling to display decimal digits required

E. Control Program
   1. Provide Controller program printout with annotation for the I/O, storage registers, results, and functions. Programs to include brief periodic descriptions of process area's system and specific operation performed. Control elements annotated to indicate function, description/tag, range, or other details.

F. Graphics
   1. Graphics shall be provided in cartoon format. Provide operator interface system program printouts:
      a. Color prints of each graphic screen
      b. Printout of graphic I/O and function block database, including all data fields available

G. Reports
   1. Provide printouts of example reports
   2. Reports to include:
      a. Accumulated total flow for each flow signal at midnight of each day
      b. Regulatory agency-mandated data

2.03 SOFTWARE MEDIA

A. Programming Software
   1. Controller and OIT manufacturer's original programming software media and documentation shall be kept complete and on-site.
   2. Upon receipt from the manufacturer, the warranties and registrations shall be provided to the Construction Manager for completion by the Owner.

B. Application Software
   1. Additional Operator Interface and/or Computer manufacturer's software media and documentation shall be kept complete and on-site.
   2. Upon receipt from the Manufacturer, the warranties and registrations shall be provided to the Construction Manager for completion by the Owner.

C. Application Programs
   1. The software application programming shall be kept current on on-site media that shall be on CD-ROM or USB thumb drive, as submitted and accepted.
   2. Media shall be permanently labeled "Application Programs For (applicable) Process Area/Process System" including controller or OIT manufacturer's programming software used name; model; and revision/version, and project labeling.

2.04 PRODUCT DATA

A. Software
   1. Programming software, application software, and application program media shall be turned over to the Construction Manager upon completion of the project as a submittal.

PART 3 EXECUTION

3.01 COORDINATION

A. Scheduling
   1. The Programming Manager shall coordinate scheduling and programming activities with the Contractor's Quality Control Manager, specified in Section 01 45 20.
      a. System schedules shall be coordinated prior to Progress Meetings.
      b. Programming status spreadsheets shall be presented at Progress Meetings.
      c. No programs will be considered substantially complete until all programming and related testing activities are determined complete by the Construction Manager.

B. Related Contract Document And Product Submittals
   1. The Contractor shall provide Programming Manager with the referenced and pertinent Specifications and Drawings with Addenda updates marked to indicate submitted and requested deviations from the specified and indicated requirements.
   2. The Contractor shall provide current reviewed product submittals for the instruments, analyzers, VFDs, MCCs, control panels, and vendor or manufacturer packaged control systems to the Programming Manager.

C. Changes
   1. The Contractor shall provide copies of the pertinent contract correspondence which may effect control system changes to the Programming Manager.
   2. The Programming Manager may request information and clarifications in a Request For Information (RFI) that is routed through the Contractor.

D. Temporary Facilities
   1. The Contractor shall provide temporary power, network connections, personal communication devices such as radios, work surfaces, and chairs as required for Programmer to insure controller and operator interface readiness prior to loop tests and to complete the testing.

3.02 PROGRAMMING EXECUTION

A. Scheduling
   1. The Programming Manager shall coordinate with the Contractor and prioritize programming in the order of schedule completion.

B. Sequence Tasks
   1. Programming shall be performed in the following order:
      a. Control description approval
      b. I/O interface summary approval
      c. Program I/O and annotation
      d. Program controller program
      e. “Force” or simulate I/O and verify/debug controller program
      f. Program graphics database
      g. Program graphics
      h. “Force” or simulate I/O and verify/debug graphics
      i. Program and verify/debug reports

3.03 TESTS

A. The Programming Manager or designated programmer shall witness and assist with Loop Tests, Functional Tests, and Operational Tests as outlined in Sections 01 45 20 and 40 61 21.

B. A minimum of 32 man-hours shall be provided per each of the process systems identified in Section 40 61 96. Programming errors noted shall be corrected during tests. Contractor shall keep on site and submit a log on the request of the Construction Manager for the Tests and man-hours expended.

3.04 TRAINING

1. The Programming Manager shall conduct application program/process operation training conforming to the requirements of Section 01 79 00. A minimum of 2 sessions of 8 man-hours on-site including training materials and expenses shall be provided, one for each of 2 shifts of 4 operators.
2. The Programming Manager shall conduct application program maintenance, modification, and re-loading training conforming to the requirements of Section 01 79 00. A minimum of 4 man-hours on-site, including training materials and expenses, shall be provided for 2 maintenance personnel.

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SECTION 40 68 13

PROCESS CONTROL (HMI) SOFTWARE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies software systems for the process control system real-time human-machine interface (HMI) and historical data management system. The programming and configuration of these software systems shall be performed in accordance with Division 40.

1.02 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's product literature for all software systems
   2. Manufacturer's recommended hardware requirements for optimum operation of each software system
   3. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. This specification is based on Inductive Automation's Ignition HMI products and, by virtue of this reference, establishes the level of performance, functionality, and quality for any products offered in lieu of the referenced products including the named manufacturers. Upon election to use products of another manufacturer, named or otherwise, the Contractor shall be responsible for all changes required in hardware and software configuration to provide the established level of performance and quality.

B. The process control software systems are listed in the "Proposed Major Equipment Supplier List" in the Contract Documents. The acceptable manufacturers of process control software systems are as follows:
   1. Real-time HMI
      a. Inductive Automation Ignition HMI
   2. Process Database System
      a. Microsoft SQL Server

C. Substitutions to the above listed manufacturers may be offered by the Contractor in accordance with the Instructions to Bidders.

2.02 SOFTWARE LICENSING

A. All process control system software products shall be licensed in the Owner's name. The number of licenses for each process control system server application including communication drivers shall be as required to implement the process control system as specified herein and detailed on the Drawings. The number of licenses for process control system client applications shall be as specified in Table 2.02:

Table 2.02

Software Application	Number of Licensed Copies	Notes
Process Control System Real-time HMI Data Server, Client and Trending	1	Unlimited tag count, Development license, includes PLC communications drivers, Ethernet driver, and configuration utilities.
Process Control System Real-time HMI Data Server, Client and Trending	2	Unlimited tag count, Runtime license
Historical Data Management System	1	

PART 3 EXECUTION

3.01 PROCESS CONTROL SOFTWARE SYSTEM PROGRAMMING

A. Process control system software shall be programmed and configured in accordance with the requirements of Division 40.

3.02 TRAINING

A. Contractor shall include as work of this specification the cost of all enrollment fees, round trip air travel, local ground transportation, and lodging for 4 of the Owner's personnel to attend a 2-day training course addressing the programming and development of the process control software systems.

B. The Contractor shall provide the services of the systems integrator for the purpose of training the Owner's personnel in the proper operation of the process control system graphical operator interface.

C. Training shall address the use of each graphical interface display and the underlying control logic associated with each control and monitoring function as well as the use of all system utilities.

D. Training shall consist of 16 hours of classroom training conducted in two 4-hour sessions per day. The same material shall be presented in each session.

E. Training shall comply with Section 01 79 00 and Section 01 99 90.

END OF SECTION

SECTION 40 71 00

FLOW MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process flow transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process flow activated switches, devices, and accessories.

D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70. Application requirements are specified in the instrument schedule, Section 40 06 70.

1.02 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References: References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:

   a. Section 01 79 00 – Demonstration and Training

b. Section 01 78 23 – Operating and Maintenance Data
c. Section 40 61 13 – Process Control System General Provisions
d. Section 40 06 70 – Instrument Index

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 VDC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers.
   8. Switch range shall be selected so that the specified set point is at least 30% but not more than 70% of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with this specification shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 VDC with the default range of 0 to 100% linearly corresponding to 4 to 20 mA.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or approved equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or approved equal.

9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier.
10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2-1/2" milliammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within 2% of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Measurement Technology LTD Type MT3042, Stahl Series 9000, or approved equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 mA, and error shall not exceed 0.1% of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc/5.5VPL/-RF, DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in paragraph 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2" stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.
   5. Flushing/Calibration Connection: Provide a tee and isolation valve between the root or gauge valve and the instrument or diaphragm seal.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.

3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

A. Applicable testing requirements are specified in Section 40 06 70.

B. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
FM	Magnetic Flow Transmitter	Flow Measurement
FTS	Thermal Flow Switch	Flow Measurement
FVA2	Variable Area Flow Meter	Flow Measurement

4.02 INSTRUMENT IDENTIFICATION: FM

A. Instrument Function: Flow Measurement

B. Instrument Description: Magnetic Flow Metering System

C. Signal Input: Process

D. Signal Output: Analog signal as specified in this section

E. Process Connection:
   1. Flow tubes of less than 4" diameter may be wafer-style ductile-iron or full-body flanged construction.
   2. Flow tubes larger than above shall be flanged, ANSI B16.5, Class 150, raised face.
   3. Flow tubes larger than 30 inches shall be AWWA Class D carbon steel flanges.

F. Product Requirements: Magnetic flow meter provided as a system consisting of a flow tube with separate indicating transmitter, unless otherwise scheduled in the Section 40 06 70 Instrument Index, complete with interconnecting cables of sufficient length between the flow tube and the transmitter. Magnetic flow meters to be used for drinking water shall be NSF approved. Contractor shall confirm compatibility of flow meter for potentially low-conductive fluid measurement.
   1. Indicating transmitter for full-scale flow rates from 1.0 to 30 feet per second. System error shall not exceed the greater of 0.5% of flowrate or 0.1 foot per second from 3 to 30 feet per second.
   2. Flow Tube: Shall be rated NEMA 6P for continuous submergence up to 20 feet. Flow tube shall be suitable for installation in "Hazardous" classified spaces.
   3. Grounding Rings: Provide up-stream and downstream 316L stainless steel grounding rings shall be fabricated from the same metal as for the electrodes below.
   4. Electrodes: Shall have conical shaped probes that are cleaned by the velocity of the flow stream. Probes shall be manufactured of 316L stainless steel unless otherwise specified.

5. Liner: As follows unless otherwise specified.
    a. Less than a 4” diameter shall be provided with metallic mesh reinforced PFA liners.
    b. 6” to 30” diameters shall be hard rubber, NSF approved liners.
    c. 30 inches in diameter and larger shall have [Hard rubber, Polyurethane] liners.
6. Transmitter: Contain electronics associated with the magnetic flow meter system. Enclosure rating NEMA-4X, cast aluminum or metal compartment for power, field connections and calibration adjustments separate from digital circuitry.
    a. Means to calibrate the metering system without use of external calibration units. Transmitter self-diagnostics. Traceability certificate of actual flow lab certification provided with each flowtube.
    b. Integral 4-digit LCD flow indication calibrated in process units. Data retained in non-volatile memory.
    c. Internal circuitry to drive flow signal to zero upon flow meter determined empty pipe condition.

G. Manufacturers:
    a. ABB Magmaster MFE
    b. Endress + Hauser Promag 50W/53W
    c. Krohne Optiflux 4000 (Optiflux 4300 for polymer feed)
    d. Or approved equal.

4.03 INSTRUMENT IDENTIFICATION: FTS

A. Instrument Function: Flow Measurement

B. Instrument Description: Thermal Flow Switch

C. Power Supply: 24 VDC

D. Signal Input: Process

E. Signal Output: Contact as specified in this section

F. Process Connection: As specified

G. Product Requirements:
1. Flow switch shall be the thermal convection type. Switch point shall not be affected by process fluid temperature changes in the range of 32 to 140°F and shall have a repeatability of ±5% of range.
2. Control unit shall operate with the specified repeatability in an ambient temperature range of 25 to 120°F.

H. Approved Manufacturers: Fluid Components Inc., Flow Technology Inc., or equal.

I. Execution: Install in accordance with manufacturer's instructions.

4.04 INSTRUMENT IDENTIFICATION: FVA2

A. Instrument Function: Flow measurement

B. Instrument Description: Variable area flow meter

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: Contacts, when specified, shall be in accordance with this section.

F. Process Connection: Flange, ANSI B16.5, Class 150, raised face, unless otherwise specified

G. Product Data: Flowmeter shall be straight-through construction with a borosilicate glass metering tube. Float shall be 316 stainless steel unless otherwise noted. 200 mm minimum length detachable aluminum scale shall be engraved in direct reading units.
   1. Maximum working pressure shall be at least 75 psig at 200°F. Accuracy shall be ± 2.0% of scale or better above 10% of scale.
   2. When specified in Section 40 06 70, flowmeter shall be equipped with a hermetically sealed reed switch with a biasing magnet.
   3. Switch shall be sealed in a shock absorbing housing and shall be actuated by a permanent magnet embedded in the metering float. Switch shall be adjustable over the entire range of the meter.

H. Execution:
   1. Installation: Install in accordance with the manufacturer's instructions.
   2. Test: In accordance with Section 40 06 70.
   3. Application/Calibration: Application, calibration, and set points shall be as specified in Section 40 06 70.
   4. Manufacturers:
      a. Brooks model 1121
      b. Or approved equal.

END OF SECTION

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SECTION 40 72 00

LEVEL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process level transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process level activated switches, devices, and accessories.

D. Scope:

1. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70. Application requirements are specified in the instrument schedule, Section 40 06 70.

1.02 QUALITY ASSURANCE

A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
   a. Section 01 79 00 – Demonstration and Training
   b. Section 01 78 23 – Operating and Maintenance Data

c. Section 40 61 13 - Process Control System General Provisions

d. Section 40 06 70 – Instrument Index

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 PRODUCT DATA

A. General:

1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 VDC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in Section 40 78 00.
   8. Switch range shall be selected so that the specified set point is at least 30% but not more than 70% of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with this section shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 VDC with the default range of 0 to 100% linearly corresponding to 4 to 20 mA.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or approved equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or approved equal.
   9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in this section.
   10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5" milliammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Measurement Technology LTD Type MT3042 or Stahl Series 9000, or approved equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 - 20 mA, and error shall not exceed 0.1% of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:

1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
    a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
    b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
    c. Pipe between the process connection and instruments shall be 1/2" stainless steel with treatment material for easy removal, as specified herein.
2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
3. Root Valves: Root valves shall be provided at all process taps, except as follows:
    a. Temperature taps, where valves are unnecessary.
    b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
    c. Process taps for safety instruments.
    d. Where gauge valves are provided.
    e. Where chemical seals are used.
4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.

C. Tubing:

1. Tubing shall be installed on supports spaced not more than 3' apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8" from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2'.

3.02 TESTING

A. Applicable testing requirements are specified in Section 40 06 70.

B. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
LFS	Float Switch, Free floating	Level Measurement
LRM	Radar Level Transmitter (Pulse)	Level Measurement
LSS	Side-Mounted Float Switch	Level Measurement

4.02 INSTRUMENT IDENTIFICATION: LFS

A. Instrument Function: Level Measurement

B. Instrument Description: Float Switch, Free-floating

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: Contacts, in accordance with this section.

F. Process Connection: N/A

G. Product Data:

1. Switch shall be free-floating type, suspended from an oil resistant waterproof cable. The cable designed to support the weight of the float without additional strain relief and permanently sealed where it enters the float body.
2. The conductors shall be a minimum size of 18 AWG. The switch shall be a SPDT dry contact type and rated at not less than 10 A at 120 VAC. The float shall have a PVC or ABS corrosion and impact resistant shell and be NSF approved.

H. Execution:
   1. Installation: Install in accordance with the manufacturer's instructions, Section 40 06 70, and the specified functional requirements.
   2. Test: In accordance with Section 40 06 70.
   3. Application/Calibration: In accordance with Section 40 06 70. Switch set point and reset point adjusted as specified.

I. Approved Manufacturers: Magnetrol Model T10, Dwyer FSW2, or approved equal.

4.03 INSTRUMENT IDENTIFICATION: LRM

A. Instrument Function: Level Measurement

B. Instrument Description: Radar Level Transmitter:

C. Pulse Type: Loop Powered

D. Power Supply: 24 VDC

E. Signal Input Process

F. Signal Output: As specified in this section

G. Signal Converter/Transmitter:
   1. Signal type: 6.3 to 26 GHz range with the maximum output power of 100 milliwatt.
   2. Enclosure: NEMA 4X [integral] mount.
   3. Operator Interface: LCD display, scaled in engineering units, with soft-keys for scrolling and configuration.
   4. Networks: HART
   5. Measuring range: 0 - 33’
   6. Accuracy: ±0.2”
   7. Analog Output: One isolated 4-20 mA, minimum of 300 ohms
   8. Ambient Temperature Range: -20 to +140°F.
   9. Process Temperature Range: -40 to +300°F
   10. Pressure Range: full vacuum to 580 psig.
   11. Sensor: As noted in the schedule
   12. Process Connection: As noted in the schedule
   13. Wetted Materials: 316 SS, PTFE, PP, or as approved.
   14. Accessories:
      a. Provide stainless steel mounting hardware, including stainless brackets, flanges, and cable length glands.
      b. Provide remote level indication where noted.
   15. Acceptable Manufacturer:
      a. Vega Vegapuls 11
      b. Or approved equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and the Engineer's installation detail.
   2. Contractor to verify size and type of specified tank connection with approved tank submittals.

4.04 INSTRUMENT IDENTIFICATION: LSS

A. Instrument Function: Level Measurement

B. Instrument Description: Side-mounted float Switch

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: Contacts, in accordance with this section.

F. Process Connection: 1" female NPT

G. Product Data:
   1. Switch stem and float shall be polypropylene unless otherwise specified. Switch shall be SPDT rated at 15 A.
   2. The switch rated for use in Class I, Division 1, Groups BCD hazardous areas. The housing rated NEMA 4X. The float magnetically coupled to the switch such that no seals are required. The process temperature rating to 220°F and the pressure rating of -15 to +2250 psig.

H. Execution:
   1. Installation: Install in accordance with the manufacturer's instructions, Section 40 06 70, and the specified functional requirements.
   2. Test: In accordance with Section 40 06 70.
   3. Application/Calibration: In accordance with Section 40 06 70. Switch set point and reset point adjusted as specified.

I. Approved Manufacturers: Delta Controls type 735, or approved equal.

END OF SECTION

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SECTION 40 73 00

PRESSURE, STRAIN, AND FORCE MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process pressure transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process pressure activated switches, devices, and accessories.

D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Sections 40 61 13 and Section 40 06 70. Application requirements are specified in the instrument schedule.

1.02 QUALITY ASSURANCE

A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
      a. Section 01 79 00 – Demonstration and Training
      b. Section 01 78 23 – Operating and Maintenance Data
      c. Section 40 61 13 – Process Control System General Provision

d. Section 40 06 70 – Instrument Index

2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
3. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
4. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
5. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
6. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
7. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
8. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
9. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00 the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 VDC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in Section 40 78 00.
   8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70% of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with this section shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 VDC with the default range of 0 to 100% linearly corresponding to 4 to 20 mA.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or approved equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A, or approved equal.
   9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier.
   10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in in this section connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Measurement Technology LTD Type MT3042, Stahl Series 9000, or approved equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 mA, and error shall not exceed 0.1% of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc/5.5VPL/-RF [DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2" stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.
   5. Flushing/Calibration Connection: Provide a tee and isolation valve between the root or gauge valve and the instrument or diaphragm seal.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3’ apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8” from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:
   1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2’.

A. Outdoor Transmitters:
   1. Transmitters mounted outdoors shall be provided with rain/sun hood per Drawing Details.

3.02 TESTING

A. Applicable testing requirements are specified in Section 40 06 70.

B. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
PDHS	Differential Pressure Indicating Switch	Pressure Measurement
PG	Pressure gauge	Pressure measurement
PGT	Gauge Pressure Transmitter	Pressure Measurement
PS	Pressure Switch	Pressure Measurement
WS	Floor Scale	Weight Measurement

4.02 INSTRUMENT IDENTIFICATION: PDHS

A. Instrument Function: Pressure Measurement

B. Instrument Description: Differential Pressure Switch

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: Contacts, in accordance with this section.

F. Process Connection: 1/4-inch male NPT

G. Product Data:
   1. Gauge: Differential pressure switch shall have a 4-1/2", 210 degree dial face with shatterproof glass window. Bourdon tube shall be bronze unless otherwise specified. Gauges manufactured to Grade A accuracy (±2.5%) in compliance with ANSI specification B40.1. The zero position shall be at the 105-degree point on the dial.
   2. Switch: The number and type of switches as specified in Section 40 06 70.
   3. The switch points visible on the face of the gauge. The switch set point externally adjustable, using a tamper proof key. The contacts set to open or close at the set point.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions, Section 40 06 70, and the specified functional requirements.
   2. Differential pressure indicating switch mounted on a separate stand and connected to the device using 3/8-inch copper tubing in accordance with Part 3 of this section.

I. Test: In accordance with Section 40 06 70.

J. Application/Calibration: Application, calibration, and set points as specified in Section 40 06 70.

K. Approved Manufacturers: Ashcroft Type 1125A with model 2265 electric contact accessory, or approved equal.

4.03 INSTRUMENT IDENTIFICATION: PG

A. Instrument Function: Pressure measurement

B. Instrument Description: Pressure gauge

C. Power Supply: N/A

D. Signal Input: N/A

E. Signal Output: N/A

F. Process Connection: 1/2" male NPT

G. Product Requirements: Pressure gauges shall be 4-1/2-“ premium grade, glycerin filled units with bourdon tube element, 270-degree milled stainless steel movement, phenolic case, and shatterproof glass window. Accuracy shall be 1% of span or better. All exposed metal parts shall be stainless steel. Pressure gauge manufacturers:
   1. Ashcroft Duragauge Figure 1279
   2. Ametek 1981L
   3. Or approved equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and the recommendations of API RP551 to the specified requirements.

      Root valves shall be provided at all process pressure taps except taps made for safety instruments. Gauge valves shall be provided at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.

      Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording. Unless otherwise specified, pressure instruments shall be located as close as practical to the process tap but shall be positioned to permit observation and maintenance. Pressure gauges may be supported from the process tap if this location permits observation from the floor or a permanent work platform. Pressure instruments shall be installed in such a manner that blowout discs are not obstructed.
   2. Application/Calibration: Application, calibration, and set points shall be as specified in Section 40 06 70.

4.04 INSTRUMENT IDENTIFICATION: PGT

A. Instrument Function: Pressure Measurement

B. Instrument Description: Gauge Pressure Transmitter

C. Power Supply: Loop powered, as specified in this section

D. Signal Input: Process

E. Signal Output: Analog transmission signal as specified in this section

F. Process Connection: 1/2" female NPT flange adapter

G. Product Requirements:
   1. Pressure Transmitter: Capacitance or piezoresistive type.
   2. Wetted Parts: Type 316 stainless steel or as specified in Section 40 06 70.
   3. Range: 100:1.
   4. Accuracy: 0.075% of calibrated span.
   5. Static Pressure Rating: 2,000 psi.
   6. Indicator: LCD display.
   7. HART standard data communication protocol
   8. Acceptable Manufacturer:
      a. Rosemount 3051CG.
      b. Or approved equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and the Engineer's installation detail.
   2. Root valves provided at all process pressure taps.
   3. Gauge valves provided at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
   4. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording.
   5. Pressure instruments located as close as practical to the process tap and be positioned to permit observation and maintenance.
   6. Pressure instruments shall not be supported from process piping.
   7. Pressure instruments for use with integral seals, or remote seals and capillary tubing provided by a single manufacturer, and all components factory-assembled prior to shipping.

I. Seals:
   1. Type: Diaphragm
   2. Process Connection: 3-1/2" saddle style, flush surface or inline style.
   3. Diaphragm and Wetted Parts: Type 316L stainless steel unless otherwise specified.
   4. Upper Housing and Mounting Flange: Type 316L stainless steel. Lower Housing: Type 316 stainless steel
   5. Temperature Limit, High Side: -40 - 300°F
   6. Acceptable Manufacturer:
      a. Rosemount 1199.
      b. Or approved equal.

J. Capillary option:
   1. Seal Location: High pressure side of transmitter, direct mounting.
   2. Fill Fluid: DC 200 Silicone
   3. Capillary Seal Connection Material: Type 316 stainless steel armored sleeving

4.05 INSTRUMENT IDENTIFICATION: PS

A. Instrument Function: Pressure Measurement

B. Instrument Description: Pressure Switch

C. Signal Input: Process

D. Signal Output: As specified in this section

E. Process Connection: 1/2" female NPT

F. Product Requirements:
   1. Pressure switch shall consist of a pressure transducer and a precision switch. Pressure transducer shall be the diaphragm piston type with wetted materials as recommended by the switch manufacturer. Piston backed by a cylinder disc to permit 10 times over-range pressure without affecting calibration.
   2. Range spring and piston shall be isolated from process fluids by the diaphragm. Switch provided with two 3/4" conduit connections. Switch assembly housing shall be cast aluminum rated types 3, 4, and 7D per NEMA ICS6. Contractor shall select pressure transducer so that set point falls between 30% and 70% of maximum range.
   3. Approximate set point and, if applicable, reset point indicated on calibrated scales. Repeatability and sensitivity shall be 1.0% of operating range. Unless otherwise specified, switches nonadjustable deadband type.

G. Approved Manufacturers: SOR Inc. Static-O-Ring, Mercoid Series 1000, or approved equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and to the specified requirements.
   2. Application/Calibration: Application, calibration, and set points as specified in Section 40 06 70.

4.06 INSTRUMENT IDENTIFICATION: WS

A. Instrument Function: Weight Measurement

B. Instrument Description: Floor Scale

C. Power Supply: 120 VAC, 60 Hz, nominal

D. Signal Input: N/A

E. Signal Output: 4 – 20 mAAs specified in paragraph 2.02

F. Process Connection: N/A

G. Product Requirements: Platform floor scale rated for industrial use with an analog 4 – 20 mA output..

H. Construction:
   1. Stainless steel platform
   2. Stainless steel load cells
   3. Platform Dimensions: 48" x 48", no more than 3" high

I. Parameters:
   1. Power Requirements: 120 VAC, 60 Hz
   2. Accuracy: 0.1% of full scale
   3. Operating Temperature: -14 – 104°F
   4. Display: 1" LCD with annunciators with pushbuttons for tare and conversion
   5. Nominal Resolution: 1:5000
   6. Maximum Weight: 2500 lb
   7. Overload Condition: Warning display at 102% of scale capacity
   8. Display Speed: 0.5 seconds, adjustable

J. Approved Manufacturers: Arlyn Scales, or approved equal.

K. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and to the specified requirements.
   2. Calibration: Calibration and set points per manufacturer's recommendation.

END OF SECTION

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SECTION 40 74 00

TEMPERATURE MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process temperature transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process temperature activated switches, devices, and accessories.

D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70. Application requirements are specified in the instrument schedule, Section 40 06 70.

1.02 QUALITY ASSURANCE

A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
      a. Section 01 79 00 – Demonstration and Training
      b. Section 01 78 23 – Operating and Maintenance Data
      c. Section 40 61 13 – Process Control System General Provisions

d. Section 40 06 70 – Instrument Index

2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
3. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
4. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
5. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
6. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
7. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
   c. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
8. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 PRODUCT DATA

A. General:
   1. In accordance with Section 01 33 00 the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in Section 40 78 00 01.
   8. Switch range shall be selected so that the specified set point is at least 30% but not more than 70% of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with this section shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 VDC with the default range of 0 to 100% linearly corresponding to 4 to 20 mA.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters and analyzers located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or approved equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or approved equal.
   9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in this section.
   10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in this sectionconnected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5" milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Measurement Technology LTD Type MT3042 or Stahl Series 9000, or approved equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 - 20 mA, and error shall not exceed 0.1% of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2" stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently
      c. installed. Isolation valves shall be provided.
      d. Process taps for safety instruments.
      e. Where gauge valves are provided.
      f. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3' apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8" from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:
   1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2'.

3.02 TESTING

A. Applicable testing requirements are specified in Section 40 06 70.

B. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
TI	Temperature indicator	Temperature measurement
TMP	Temperature Transmitter	Temperature measurement
TRE	Resistance temperature insertion type RTD	Temperature measurement

4.02 INSTRUMENT IDENTIFICATION: TI

A. Instrument Function: Temperature measurement

B. Instrument Description: Temperature indicator

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: N/A

F. Process Connection: 1/2-inch male NPT

G. Product Requirements: Temperature indicators shall be 4-1/2” gas pressure operated bourdon tube elements, 270-degree movement, phenolic case, shatterproof glass window, and 1/2" NPT process connection.

   Bulb shall be 3 inches long by 3/8” diameter for all ranges. Stem lengths shall be selected to place bulb in middle third of pipe. Indicator head shall be swivel mounted to the stem.

H. Temperature indicator manufacturer:
   1. Ashcroft Duratemp Type 600B, or equal.

I. Execution:
   1. Installation: Temperature instruments shall be installed in accordance with the manufacturer's instructions and the recommendations of API RP551 to the specified requirements.
   2. For pipelines less than 4” diameter, temperature elements shall be installed at a pipeline elbow if possible.
   3. Where an elbow is not available, a wye fitting shall be installed in the pipeline for installation of the temperature element at a 45-degree angle with the flow.

4.03 INSTRUMENT IDENTIFICATION: TMP

A. Instrument Function: Temperature Measurement

B. Instrument Description: Temperature Transmitter

C. Power Supply: As specified in this section

D. Signal Input: Process temperature monitored by RTD

E. Signal Output: Analog transmission signal as specified in this section

F. Process Connection: Integral or remote mounting to sensor and thermowell, as specified in Section 40 71 00.

G. Product Requirements:
   1. Temperature Transmitter: 2-wire device, powered from the PLC analog input power supply.
   2. Temperature Limits: 0 - 160°F.
   3. Humidity Limits: 0 - 100% RH.
   4. Accuracy: 0.25°F + 0.02% span, using 100 Ohm Platinum RTD.
   5. Output: One isolated 4-20 mA into a maximum of 600 ohms.
   6. Sensor update time: 0.5 seconds.
   7. Failure mode: Transmitter shall have a configurable failure mode to drive the analog signal either high (>21 mA) or low (<3.75 mA) in the event of microprocessor failure.
   8. Rating: NEMA 4X or as specified in 40 06 70 Instrument Index.
   9. Indicator: LCD display.
   10. Acceptable Manufacturers:
      a. Rosemount 3144P.
      b. Central Station Steam CSTMP Series.
      c. Or approved equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and the Engineer’s installation detail.

4.04 INSTRUMENT IDENTIFICATION: TRE

A. Instrument Function: Temperature measurement

B. Instrument Description: Resistance temperature detector element, inserting type

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: 100 ohms nominal at 0 degrees C, resistance temperature coefficient of 0.385%/degree C

F. Process Connection: 1/2" male NPT

G. Product Requirements:
   1. Temperature element shall be tip sensitive, three- or four-wire platinum resistance temperature detector (RTD) in 1/4" ASTM A269, Type 316 stainless steel sheath with watertight connection head.
   2. Time constant in agitated water shall not exceed 8 seconds. RTD shall comply with ASTM E1137, tolerance Grade A
   3. RTDs for installation in wells shall be provided with spring loading device and union coupler. Union shall extend out beyond pipe lagging.
   4. Three- or four-wire lead configuration for ambient temperature compensation shall be provided. RTD extension cable conductors shall be shielded triads as specified in Division 26.
   5. Bushings and wells for temperature elements shall comply with ASME B40.200 and unless otherwise specified shall be machined from ASTM A276, Type 316 stainless steel bar stock. Union couplers shall be provided for all temperature elements.

H. Execution:
   1. Installation: Temperature elements shall be installed in accordance with the manufacturer's instructions.

END OF SECTION

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SECTION 40 75 00

PROCESS LIQUID ANALYTICAL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for process fluid analyzer indicating transmitters.

1.02 REFERENCES

A. References shall be as specified in Section 40 61 13.

1.03 SUBMITTALS

A. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
   a. Section 01 79 00 – Demonstration and Training
   b. Section 01 78 23 – Operating and Maintenance Data
   c. Section 40 61 13 – Process Control System General Provisions
   d. Section 40 06 70 – Instrument Index

   A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

   The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal.

   If no changes are required, the drawing or drawings shall be *marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.*

3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. *Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.*

4. Marked product literature of all equipment and features to be provided.
    a. Installation drawings for only the analyzers, sensors, and mounting accessories to be provided.
    b. Electrical and signal connection drawings for only the analyzers and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, replenishment parts, and chemicals that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 40 61 13.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the candidate manufacturers listed in the INSTRUSPEC sheets included in this Section are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

2.02 GENERAL

A. Process fluid analyzers shall comply with the following requirements:
    1. Measured parameter output indicators shall be calibrated in process engineering units.
    2. Two wire Analyzers shall be 4 to 20 mA output with operating power derived from the signal transmission circuit.
    3. Transmitter shall support an external load of 0 to 500 ohms with the power supply at a nominal 24 VDC with the range of 0 to 100% corresponding to 4 to 20 mA.
    4. Transmitter output shall be galvanically isolated from the process and the analyzer case.
    5. Analyzers located outdoors shall be provided with surge protectors.
        a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or accepted equal.
        b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
    6. Transmitter output shall increase with increasing process measurement, except where specified as "reverse action" in the Instrument Index.
    7. Electrical parts of analyzer transmitter and/or primary element mechanisms shall housed in enclosures meeting NEMA 250, Type 4 requirements.
    8. Electrical equipment and analyzer transmitters located outdoors or in areas specified as corrosive shall have enclosures meeting NEMA 250, Type 4X requirements.
    9. Two-wire transmitters, located in a facility hazardous classified area per the NFPA and the NEC, shall be made safe by an intrinsic safety barrier.

10. Four-wire transmitters shall be isolated from the process and power or be provided with a loop-powered signal current isolatorand shall be connected in the output signal circuit.
11. One analyzer transmitter shall be provided for each sensor. Dual sensor analyzer capability shall not be utilized.

2.03 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each analyzer.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation requirements are specified in Section 40 61 13.

3.02 TESTING

A. Testing requirements are specified in Section 40 61 21.

3.03 TRAINING

A. Training requirements are specified in Sections 01 79 00 and 40 61 13. Provide two training sessions, each with one hour per type of analyzer.

3.04 INSTRUMENTATION SPECIFICATION (INSTRUSPEC) SHEETS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, Section 40 70 00, and/or on the drawings.

B. INSTRUSPEC sheets for the analyzers listed in the following Table A are included in this paragraph:

Table A: List of Process Fluid Analyzer Indicating Transmitters

INSTRUSPEC Symbol	Analyzer Description	Instrument Function
AC	Conductivity Analyzer	Analyzer Indicating Transmitter
SC	Streaming Current	Analyzer Indicating Transmitter
AH	Hydrogen-ion Analyzer (pH)	Analyzer Indicating Transmitter
PC	Particle Counter	Analyzer Indicating Transmitter
ATI	Optical Turbidimeter Analyzer	Analyzer Indicating Transmitter
CLR	Chlorine Residual Analyzer	Analyzer Indicating Transmitter
FL	Fluoride Analyzer	Analyzer Indicating Transmitter

3.05 AC INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: AC

B. Instrument Description: Conductivity Analyzer

C. Power Supply: 120 VAC

D. Signal Output:
   1. 4 to 20 mA into 0 to 500 ohms, isolated
   2. Two Form C relay outputs

E. Process Connection: Insertion

F. Product Requirements:
   1. Analyzer: Analyzer transmitter shall be pipe/surface mount, NEMA 4X with integral keypad/display and self-diagnostics, system FM approved for Class I Division 2 hazardous area. Unit shall be Invensys/Foxboro 875EC, Emerson/Rosemount 1066, or approved equal.
   2. Sensor: Conductivity measurement shall be made with an electrode-less sensor with epoxy or glass-filled polyetheretherketone (PEEK) encapsulated large bore toroidal sensor body with integral temperature sensor designed for immersion service water quality monitoring. Sensor shall be Invensys/Foxboro 871EC-EV, Emerson/Rosemount 226, or approved equal.
   3. Junction Box: Invensys/Foxboro 51052, Emerson/Rosemount 23550-00, or approved equal.
   4. Extension Cable: Invensys/Foxboro 6000130, Emerson/Rosemount 23294-04, or approved equal.
   5. Calibration Buffers: Two sets of two different conductivity buffers. Use one set for testing/calibration and training, second set for Owner.
   6. Insertion Mounting: Accessories as required for the installation specified on the drawings, provided by sensor Manufacturer.

G. Execution:
   1. Installation: Insertion assemblies shall be installed per Manufacturer instructions.

3.06 SC INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: SC

B. Instrument Description: Streaming Current monitor

C. Power Supply: 120 VAC

D. Signal Output:
   1. 4 to 20 mA into 0 to 500 ohms, isolated
   2. Two Form C relay outputs, minimum

E. Process Connection: ½ in BSP, flow-through

F. Product Requirements:
   1. Measure optimization of coagulation process in drinking water and shall be Hach AF7000, or approved equal.
   2. Operating Ranges:
      a. Humidity: Maximum relative humidity 95% for temperatures up to 122°F
      b. Temperature: 0 – 122°F at 95 relative humidity (non-condensing)
   3. Outputs:
      a. 4 – 20 mA, isolated, maximum load 500 ohms
      b. 2 SPST relays, 5 A, 30 VDC resistive loads
   4. Response time: 1 – 60 seconds, adjustable average
   5. Sample flow rate: 2 – 4 L/min, variable
   6. Sample temperature: 45 – 95°F
   7. Wetted materials: stainless steel, UHMW, epoxy
   8. Options: Parts and kit(s) necessary for auto flush and water connection (115 VAC)

G. Execution:
   1. Installation: Installed in accordance with the manufacturer's recommendation.
   2. Application/Calibration: In accordance with manufacturer's calibration procedures.
   3. Calibration: Calibrate with the Owner. Schedule Owner's Lab and maintenance personnel in advance with the Construction Manager.
   4. Manufacturer Services: One day per analyzer on-site, minimum two days.

3.07 AH INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: AH

B. Instrument Description: Hydrogen-ion Activity (pH) Analyzer

C. Power Supply: 120 VAC

D. Signal Output:
   1. One 4 to 20 mA per sensor, isolated
   2. Three Form-C relay outputs

E. Process Connection: Insertion

F. Product Requirements:
   1. Analyzer: Analyzer transmitter shall be pipe/surface mount, NEMA 4X with integral keypad/display and self-diagnostics, and shall be Hach SC4500, or approved equal.
   2. Sensor: pH measurement shall be made with a differential glass electrode, titanium ground electrode, integral preamplifier, 15 foot cable, and glass-filled polyetheretherketone (PEEK) body with 1" NPT threading on both ends. Sensor rated 100 psig, 10 fps flow with digital cable connection. Sensor shall be Hach DPD1P1, or approved equal.

3. Replenishment Parts: One salt bridge and one bottle of standard cell solution for each sensor/analyzer.
4. Junction Box: Hach / GLI 60A2053, or equal.
5. Extension Cable: Hach / GLI 1W1100, or equal.
6. Calibration Buffers: Two sets of each of pH 4 and 7 buffers. Use one set for testing/calibration and training, second set for Owner.
7. Mounting Accessories: Pipe insertion mounting kit or as required for the installation specified on the drawings, provided by sensor manufacturer

G. Execution:
1. Installation: Insertion assemblies shall be installed per manufacturer's instructions.
2. Application/Calibration: In accordance with manufacturer's recommendations.
3. Manufacturer services: Two hours per analyzer on-site, minimum one day.

3.08 PC INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: PC

B. Instrument Description: Particle Counter

C. Power Supply: 120 VAC

D. Signal Output:
1. RS485 with analog I/O
2. Three Form C relay outputs

E. Process Connection: ¼-inch OD tubing, flow-through design

F. Product Requirements:
1. Counter: Counter shall be surface mount, NEMA 4X, and shall be Hach 2200 PCX, or approved equal.
2. Sample Flow Rate: 100 mL/min
3. Operating Temperature: 0 – 122°F
4. Particle Size Range: 2 – 750 microns
5. Pressure Range: 55 psig continuous

G. Execution:
1. Installation: Counter shall be installed per manufacturer instructions.
2. Manufacturer services: Two hours per counter on-site, minimum one day.

3.09 ATI INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: ATI

B. Instrument Description: Optical Indicating Turbidimeter (ultra low range for potable water applications)

C. Power Supply: 120 VAC

D. Signal Output:
   1. 4 to 20 mA into 0 to 500 ohms, isolated
   2. Three Form C relay outputs

E. Process Connection: Input,1/4" NPT; output, 1/2" NPT

F. Product Requirements:
   1. Analyzer: Analyzer transmitter shall be pipe/surface mount, NEMA 4X with integral keypad/display and self-diagnostics, and shall be Hach SC200, or approved equal.
   2. Sensor:All optical and hydraulic components shall be housed in the turbidimeter body which shall incorporate a built-in bubble trap. 0 to 5 NTU range. Turbidimeter shall be Hach FilterTrak 660, or approved equal.
   3. Junction Box: Hach, or equal.
   4. Extension Cable: Hach 57962-00, or equal.
   5. Calibration Equipment: One Calibration Kit shall be provided consisting of a 1-liter calibration cylinder simulating the turbidimeter body and funnel, Hach 52364-00, or equal. One 1-liter calibration standard, 800 mNTU, Hach, or equal. One 1-liter verification standard, [100][300][500][5000] mNTU, Hach, or equal.

G. Execution:
   1. Installation: Installation shall be in accordance with the manufacturer's recommendations.
   2. Application/Calibration: Application, calibration, and set points shall be as specified in project documents.
   3. Manufacturer Services: Two hours per analyzer on-site, minimum one day.

3.10 CLR INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: CLR

B. Instrument Description: Chlorine Residual Analyzer

C. Power Supply: 120 VAC

D. Signal Output:
   1. 4 to 20 mA into 0 to 500 ohms, isolated
   2. Three relay outputs, configurable NO or NC

E. Process Connections: 1/2-inch NPT sample line; 1-1/4" drain line

F. Product Requirements:
   1. Analyzer: Analyzer transmitter shall be surface mount and shall be specific to free chlorine as specified.
   2. The sample-flow system shall be composed of plug-in components on a swing-out panel. It shall contain large ports throughout, grit bombardment of the measuring and counter electrodes, continuous metering of reagent chemicals and detergent into the sample, a self-cleaning main orifice and a solenoid valve for automatic back-flushing cycles.

3. A motor-driven impeller shall maintain a constant sample velocity at the measuring electrode. The reagent pump shall be a valve-less, peristaltic type with brushless stepping motor.
4. The analyzer's electronics shall be microprocessor-based with a touch key pad and alphanumeric display. Electronic components shall be housed in NEMA 4X enclosures.
5. Two security-coded menus shall give access to two levels of operation: a scrollable, informative operator's menu with easy change of operating parameters; and a supervisor's set-up menu with instructions and error messages to assure proper operation.
6. On-line and off-line diagnostics shall also be presented for servicing and calibration. The analyzer shall be easily reprogrammed for different measurement ranges.
7. Calibration accuracy shall be one percent of full scale; operating range shall be 40:1; and residual-measurement ranges shall be 0 – 10- mg/l.

G. Instrument Identification
1. Analyzer shall be Siemens/Wallace & Tiernan (W&T) Micro/2000.
2. Sensor:
a. Amperometric three electrode measuring cell. The measuring cell shall be of the flow-through type with three dissimilar metal electrodes which shall produce a signal proportional to chlorine residual.
b. The cell shall provide continuous on-line analysis of chlorine residual sensitive to one part per billion (.001 mg/l) and be capable of continuous feedback control of chlorine residual down to ten parts per billion (.01 mg/l). It shall not lose sensitivity due to extended periods of samples containing no chlorine.
3. Replacement Parts:
a. One sensor, W&T.
b. One preventive maintenance kit, W&T G2416.
4. Replenishment Parts: One bottle of electrolyte for each sensor/analyzer, W&T U28039.
5. Calibration Buffers:
a. One carton of four bottles of pH 4 reagant for each sensor/analyzer, W&T U13765.
b. Two bottles of potassium iodide for each sensor/analyzer for measuring total chlorine, W&T U23661.

H. Execution: Install and calibrate instrument in accordance with manufacturer’s recommendations.
1. Application/Calibration: In accordance with manufacturer’s recommendation. Owner will assist with calibration and provide hand-held test kit.
2. Manufacturer Services: Two hours per analyzer on-site, minimum one day.

3.11 FL INSTRUMENT SPECIFICATION SHEET–INSTRUSPEC

A. Instrument Identification: FL

B. Instrument Description: Fluoride Analyzer - Indicating Transmitter with continuous monitoring of fluoride concentration in drinking water using an ion selective electrode with replaceable tip.

C. Power Supply: 120 VAC

D. Accuracy: ±10% or ±0.10 mg/L, whichever is greater

E. Inlet Pressure: 1 – 10 psig

F. Detection Range: 0.1 – 10.0 mg/L fluoride

G. Sample Flow Rate: 200 – 500 mL/minute

H. Sample Temperature: 41 – 104°F

I. Operating Humidity: 90% at 140°F

J. Signal Outputs:
   1. 4 to 20 mA, isolated
   2. Selectable, 2 SPDT relays with contacts rated for 5 A resistive load at 230 VAC

K. Process Connections: Inlet, 1/4" OD tubing; Outlet, 1/2" ID flexible hose

L. Product Requirements:
   1. Analyzer shall be surface mount with integral keypad/display, auto calibration, and self-diagnostics. Analyzer shall be Hach CA610.
   2. Power Cable: 6' with North American plug; provided by manufacturer.

M. Execution: Installation shall be in accordance with the manufacturer's recommendations.
   1. Accessories:
      a. Maintenance kit
      b. Electrode kit
      c. Reagent set
   2. Application/Calibration: In accordance with manufacturer's recommendations.
   3. Calibration: Calibrate with the Owner. Schedule Owner's Lab and maintenance personnel in advance with the Construction Manager.
   4. Manufacturer Services: One day per analyzer on-site, minimum three days.

END OF SECTION

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SECTION 40 78 00

PANEL MOUNTED INSTRUMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies general requirements for universal case instruments which form a part of process control systems as specified in Division 40. Universal case instruments shall include complete assemblies of measuring, transmitting, control, indicating, and recording elements and accessories.

B. This section specifies requirements for panel mounted signal conditioning modules.

C. This section specifies requirements for panel mounted electronic instruments used to provide process control and interface between the operator and the process.

D. This section specifies requirements for miscellaneous panel mounted instruments used to provide process control and interface between the operator and the process.

E. Definitions:

1. Large Case Instruments: Large case instruments shall be nominally 18" high by 14" wide by 6" deep and capable of mounting one to four pressure or temperature elements and a 12" circular chart recording mechanism.
2. Medium Case Instruments: Medium case instruments shall be nominally 12" high by 10" wide by 6" deep and capable of mounting one measuring element, an eccentric scale indicator, and output functions as specified.
3. Circular Case Instruments: Circular case instruments shall accommodate one measuring element, a 6" concentric scale indicator, and electric contact control functions as specified.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ISA S51.1	Process Instrumentation Terminology
SAMA PMC6-10-63	Filled System Thermometers, 2nd edition
NEMA 250	Enclosures for Electrical Equipment
NFPA 70	National Electrical Code (NEC)
UL 1012	Power Supplies
EIA RS-310C	Racks, Panels, and Associated Equipment

1.03 PLANT ELECTRICAL SUPPLY SYSTEM

A. Electric power for instrumentation and communication systems shall be obtained from the power distribution system specified in Division 26. This power is not regulated, wave forms may be distorted, and significant amounts of electrical noise may be present. The Contractor shall provide all necessary power supply and conditioning equipment to provide electrical power of the required voltages and current capacities and of adequate quality to ensure reliable operation of the instrumentation and communication systems. Unless otherwise specified, the Contractor shall assume that the power supply for instrumentation systems is 120VAC, ±15%, 60 Hz, ± 3 Hz, 5% maximum harmonic distortion.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 61 13.01.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION (INSTRUSPEC) SHEETS

A. General requirements for instruments specified in this section and are listed on INSTRUSPEC sheets in the appendix to this section. Application requirements are specified in project documentation.

2.02 MINIATURE CASE INSTRUMENTS

A. Unless otherwise specified, panel instruments shall comply with the following requirements:
   1. Analog instruments shall be miniature-case drawout type nominally 6” H x 3” W by not more than 20” D.
   2. Operator, tuning, and configuration adjustments shall be accessible without disconnecting the instrument from the process.
   3. Analog signal indicators shall be solid-state, LED or gas-discharge type, bar-graph displays with not less than 200 segments.
   4. Analog signal inputs shall be 1 – 5VDC into not less than 250K ohms.
   5. Analog signal outputs shall be 1 – 5VDC into 10 ohms except where instrument provides final output signal to field in which case output shall be 4 - 20 mA current regulated into 0 to 600 ohms.
   6. Power supply shall be 24VDC, ±10%.
   7. Signal and power supply connections shall be galvanically isolated from the instrument case.

B. Panel instruments specified in this section shall be the product of a single manufacturer, and shall match and line up to form an integrated appearance and operator interface strategy.

2.03 UNIVERSAL CASE INSTRUMENTS

A. Cases
   1. Cases shall be nonmetallic weather and corrosion resistant types. Windows shall be shatterproof glass or Lexon plastic.

B. Measuring Elements
   1. General: Measuring elements shall include internal and/or external components as specified to produce linkage motion within the instrument case which is indicative of the measured variable.
   2. Pressure: Pressure elements shall be bellows or helicals as applicable for the specified range. Unless otherwise specified wetted materials shall be type 316 stainless steel for liquids and process gasses, and brass for instrument air and oxygen.
   3. Temperature: Temperature elements shall be SAMA PMC6-10, Type 1A. Capillary tubing and bulbs shall be type 316 stainless steel, and tubing shall be armored.
   4. Differential Pressure Unit: Differential pressure elements shall be American Meter Dri-Flo, Barton 199, or approved equal, for specified spans ≤50 psid. Differential pressure elements shall be Barton 224, Meriam 1020, or approved equal, for specified spans ≥ 50 psid.
   5. Electronic: Measurement system shall be a self-balancing servo-potentiometer with solid state electronics. Balancing system shall be step-less, utilizing noncontact or conductive plastic feedback potentiometer. Error shall not exceed 0.25% of span and deadband hysteresis shall not exceed 0.1% of span. Servo shall accept thermocouple, resistance temperature, and electronic transmission signals as specified.

C. Output Functions
   1. Current Transmission: Transmitter shall be two-wire motion-balance current-regulator type capable of driving 0 to 400Ω with a loop power supply of 24VDC. Error, including measuring element and linkages, shall not exceed 0.5% of span.
   2. Integration: Integrator shall be a mechanical type with eight-digit nonreset cyclometer. Cam cycle shall not exceed 15 seconds. Error, including measuring element and linkages shall not exceed 0.5% of span.
   3. Recorder: Recorder shall be 12-inch circular chart type with 120VAC, 60 Hz drive and capillary inking system. Chart rotation shall be 24-hour unless otherwise specified.
   4. Pneumatic Transmission: Pneumatic transmitter shall be 3 - 15 psig output motion-balance type with air delivery capacity of not less than 1.5 scfm and error, including measuring element and linkages not to exceed 0.5% of span.

5. Pneumatic Control: Pneumatic controller shall be of the motion-balance type with modes as indicated and 3 - 15 psig, 1.5 scfm minimum output. Control modes shall be as defined in ISA S51.1. Controller output shall be readily reversible without additional parts or necessitating realignment. Controllers shall be provided with a four-position (bumpless transfer type) manual/automatic transfer valve, supply gage, manual regulator, and output gage. Proportional action gain shall be continuously adjustable 0.2 - 50; integral and derivative time constants shall be adjustable from 0.2 - 30 minutes except when fast response is specified where 0.02 - 5 minutes adjustment range shall be provided. When specified, antireset wind-up is specified, relays and pneumatic circuitry shall be provided to eliminate the effect of reset wind-up when the process variable remains off set point for an extended period.
6. Electric Contacts: Electric contacts shall be provided as specified. Actuation point error shall not exceed 0.5% of span. Process switches and devices shall comply with the following requirements:
    a. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
    b. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
    c. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 - 100 mA at 24VDC.
    d. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
    e. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
    f. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
    g. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers.
    h. Switch range shall be selected so that the specified set point is at least 30% but not more than 70% of the span, between the upper range limit and the lower range limit.

2.04 SIGNAL CONDITIONING MODULES (FUNCTION MODULES):

A. Unless otherwise specified, signal conditioning modules shall comply with the following requirements:
    1. Analog signal inputs shall be 1 – 5VDC into 20 MΩ.
    2. Analog signal outputs shall be 1 – 5VDC into 20 kΩ.
    3. Discrete output contacts shall be SPDT rated 5A at 120VAC and 28VDC.
    4. Power supply shall be 24VDC, ±10%. Power supply effect shall not exceed 0.005% per 1.0%.
    5. Electronic trips shall be arranged so that output contact opens in case of loss of signal or loss of power supply.
    6. Signal and power supply terminals shall be galvanically isolated from the card cage frame.
    7. DIN-rail mounted

2.05 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Data specified in Section 40 61 13-2.03.
   2. Test results as specified in Section 40 06 70-3.02 Installed Equipment – Tests and Inspection.
   3. Catalog data including performance parameters.
   4. Wiring diagrams.
   5. Applicable operation and maintenance information as specified in Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation requirements are specified in Division 40.

B. Mount and connect instruments furnished in this section in accordance with manufacturer's instructions to the specified functional requirements.

3.02 TESTING

A. Testing requirements are specified in Division 40.

PART 4 APPENDIX INSTRUSPEC SHEETS

4.01 INSTRUSPECS

A. Table A, which follows, is edited to reflect only those instrument components which are identified in the instrument index. INSTRUSPECS are categorized generally according to function within the process system. Each sheet has an identifying symbol which should be used in the instrument index to reference the particular instruments required. Table A lists in alphabetical order by instrument identification coding the various instruments specified together with instrument function and instrument description.

Table A

INSTRUSPEC symbol	Instrument description	Instrument function
YPC	Potentiometer converter	Function module
ISS	Solid state indicator	Miscellaneous panel instrument

4.02 FUNCTION MODULE

A. Instrument Identification: YPC
   1. Instrument Function: Function module
   2. Instrument Description: Potentiometer converter
   3. Power Supply: 24VDC
   4. Signal Input: N/A
   5. Signal Output: Standard panel instrument voltage signal
   6. Process Connection: N/A
   7. Product Requirements: Potentiometer shall provide constant current slidewire excitation. Span shall be adjustable from 80 - 100% of slidewire travel; zero shall be adjustable from 0 - 10% of slidewire travel. Excitation current shall not exceed 1 mA for 1000Ω slidewires. Accuracy shall be 0.1% of span or better, time constant 50 milliseconds or less, temperature drift 0.02% of span per ºC or less over a range of 0 - 50ºC. Power supply effect shall not exceed 0.1% of span with power supplies provided. Module shall be Moore Industries, AGM Electronics, or equal.
   8. Execution: As specified in Part 3 of this section.

4.03 MISCELLANEOUS PANEL INSTRUMENTS

A. Instrument Identification: ISS
   1. Instrument Type: Miscellaneous panel instrument
   2. Instrument Description: Solid state indicator
   3. Power Input: 120VAC
   4. Signal Input: 4 – 20 mA or 1 – 5V, 10Ω minimum, 700Ω maximum loop resistance
   5. Signal Output: 4 – 20 mA
   6. Relays: 2 Form C (SPDT) rated 3A at 30VDC or 3A at 250VAC resistive load
   7. Power Supply: 24VDC
   8. Process Connection: N/A

9. Product Requirements: Indicator shall be housed in 1/8-DIN enclosure, NEMA 4X front, field programmable to accept voltage or current inputs, adjustable display brightness, 4 x 0.5" high red LED digits.
10. Execution: As specified in Part 3 of this section.

END OF SECTION

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SECTION 40 79 00

MISCELLANEOUS INSTRUMENTS, CALIBRATION EQUIPMENT, INSTRUMENT VALVES, AND FITTINGS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrument air supply equipment and pneumatic signal transmission systems and accessories. Additional requirements for mechanical equipment and piping are specified in Divisions 23, 40, 41, 43, and 46.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASME SECTION VIII	Boiler and Pressure Code, Pressure Vessels
ASTM B68	Seamless Copper Tube, Bright Annealed
ASTM D883	Definition of Terms Relating to Plastics
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ISA S7.3	Quality Standard for Instrument Air

1.03 SUBMITTALS:

A. The following information shall be submitted in accordance with Section 01 33 00:
   1. Catalog and technical data for instrument air compressor system.
   2. Outline dimensions, weight, and foundation requirements for instrument air compressor system.

PART 2 PRODUCTS

2.01 INSTRUMENT AIR COMPRESSOR SYSTEM

A. General:

1. Air compressor system shall consist of a skid assembly with the following listed components prepiped and wired to provide a complete and operable air supply system to provide instrument quality air between 60 and 75 psig in compliance with ISA S7.3. Each air compressor shall have a continuous duty capacity rating of not less than two times the air supply requirements of the instrumentation and control system including final elements.
    a. Two nonlubricated air compressors with electric motors.
    b. Air cooled aftercooler.
    c. ASME receiver with automatic drain.
    d. Dry-type intake-air filter.
    e. Moisture separator with automatic trap.
    f. Dryer.
    g. Complete control and protection package.
2. Air compressor system shall be Corken International Corporation A-90 series, or equal. Engineer knows of no equal.

B. Compressors:

1. Each compressor shall be single stage, single acting, vertical reciprocating type, requiring no lubrication in the compression cylinder(s) or valve area, and utilizing a distance-piece, cross-head, and cross-head guide between the crankcase and cylinder(s). Cylinder(s) shall be provided with two sets of self-lubricating seals on the piston rod(s). The distance piece design shall be such that no portion of the piston rod(s) which enters the crankcase and cross-head guide may alternately enter the compression cylinder(s).
2. The piston(s) shall be designed to be removable from the cylinder(s) and piston rod(s) without disturbing the cylinder(s), and shall be equipped with one-piece glass-filled self-lubricating Teflon piston rings. Rider rings are not acceptable.
3. The crankcase shall be of the atmospheric type, totally enclosed with a breather valve to prevent the entrance of foreign matter. It shall include a force-feed lubrication system for lubricating the crankshaft bearings, connecting rod bearings, wrist pins, and cross head through rifle-drilled crankshaft and connecting rod(s).

C. Motors:

1. Motors shall comply with Section 43 05 21-2.04.

D. Receiver:

1. Receiver shall be fabricated from carbon steel, shall be fitted with pressure-type handholes, and semi-elliptical pressure heads. Tank shall be provided with threaded bosses for inlet, outlet, and gage connection fitted with gauge, 1-inch drain connection fitted with an automatic drain device, and safety valve connection fitted with approved safety valve. Tank interior shall be protected with a baked marine epoxy coating, factory applied after fabrication. The coating shall be applied in two coats and shall be free of pinholes and thin spots.

2. Receiver shall meet the requirements of Section VIII, Division 1 or Division 2 of the ASME Boiler Code; and shall bear an ASME inspector's stamp, complete with design working pressure, date, and place of manufacture.

E. Control and Monitoring Equipment:
   1. Compressor system shall be provided with an automatic pressure control and monitoring panel, complete except for motor starters. Control and monitoring panel shall provide the following features:
      a. Lead/follow selector switch.
      b. Lead/follow and start/stop controls with mode selector.
      c. Individual alarm annunciators for low oil level, high discharge temperature, low receiver pressure, and dryer failure with one normally closed common contact for connection to remote monitoring equipment.
   2. Receiver shall be fitted with a pressure governor and gauge complying with the requirements of Section 40 73 00.

2.02 AIR SETS

A. Air sets shall consist of service regulator and 10 micron filter of capacity to serve 200 percent of the connected instrument or final element load. Air sets for individual field mounted instruments shall be nonadjustable or otherwise sealed to prevent tampering, shall be provided with 2-inch gage, and shall be Conoflow FH-60, Fairchild-Hiller 61112GF, or equal. Air sets for panels shall be adjustable with 3-1/2-inch or larger gage and shall be Conoflow-FH-60, Fairchild-Hiller 65232GF, or equal.

2.03 AIR SUPPLY PIPING, FITTINGS AND VALVES

A. Piping, fittings and valves shall comply with Section 40 05 01, System 2. Minimum pipe size shall be 3/8 inch for individual instrument supply connections and 1/2 inch for multiple instruments or panels with pneumatic instruments. Larger size piping shall be provided where specified.

2.04 SIGNAL PIPING, FITTINGS AND VALVES

A. Copper Tubing:
   1. Signal tubing shall be ASTM B68 DHP soft annealed copper with an ASTM D883 PVC jacket. Tubing shall be 1/4-inch O.D. by 0.03-inch wall or 3/8-inch O.D. by 0.032-inch wall as specified.

B. Stainless Steel Tubing:
   1. Tubing shall be seamless annealed ASTM A269 Type 316 stainless steel 1/2-inch and 3/8-inch tubing shall have a wall thickness of 0.035 inches and 1/4-inch tubing shall have a wall thickness of 0.028 inches.

C. Plastic Tubing:
   1. Tubing shall be extruded from high molecular weight, low density polyethylene compound. Tubing shall be 1/4-inch outside diameter and shall be black, unless otherwise specified or shown. Tubing shall meet the standard ASTM #D-1693 test for stress cracking of base materials. Wall thickness shall be 0.040 inches plus or minus 0.005 inches. Maximum working pressure shall be 80 psig, at 100 degrees F, or higher.
   2. Tubing manufacturers: Dekoron "P", Parker Hannifin "E", or equal.

D. Plastic Tubing:
   1. Plastic tubing shall be high molecular weight virgin polyethylene in accordance with ASTM D1248, Type III, Class C, Grade 3 with 0.04 inch minimum wall thickness.

E. Tubing Fittings:
   1. Tubing fittings shall be Type 316 stainless steel and shall be the double-ferrule swage type. Flare, ball sleeve compression or single-ferrule swage type are not acceptable.
   2. Fitting manufactures: Crawford "Swagelok", Hoke "Gyrolok", or equal.

F. Fittings:
   1. Fittings shall be Type 316 stainless steel. Fittings shall be of the swage ferrule design and shall have components (nut, body and ferrule system) interchangeable with those of at least one other manufacturer. Flare and ball sleeve compression type fittings are not acceptable. Fittings shall be Parker CPI, Crawford Swagelok, Hoke Gyrolok, or equal.

2.05 VALVES

A. Isolation Valves:
   1. Valves shall be full port ball valves with ASTM A276, Type 316 stainless steel trim and body and with Teflon seats and packing. Valves shall be Parker CPI, Whitey, Hoke, or equal.

B. Gage Valves:
   1. Gage valves shall be machined from ASTM A276, Type 316 stainless steel bar stock and shall be provided with 1/2-inch NPT connections and integral bleed plug. Valves shall be Anderson, Greenwood & Company M9 VIS-44, Hoke 6801L8Y, or equal.

C. Root Valves:
   1. Root valves shall be ASTM A276, Type 316 stainless steel bar stock with 1/2-inch NPT male process connection and three 1/2-inch NPT female instrument connections. One instrument connection shall be provided with an ASTM A276, Type 316 stainless steel bleed valve. ASTM A276, Type 316 stainless steel plugs shall be provided for unused ports.
   2. Lagging type units shall be provided for insulated vessels and pipes.
   3. Root valve manufactures: Anderson, Greenwood & Company M5 VIS-44, Hoke 6802L8Y, or equal.

D. Manifolds:
   1. Manifolds shall be three-valve bar-stock type. Manifold body shall be machined from ASTM Type 316 stainless steel bar stock. Valves shall be globe configuration with 316 stainless steel ball seats and Teflon stem packing.
   2. Manifolds shall be designed for direct mounting to differential pressure transmitters in place of the flanges normally furnished. Fabricated manifolds or manifolds employing needle or soft seat valves are not acceptable. Purge taps, 1/8-inch NPT shall be furnished on manifolds where water purge is specified.
   3. Manifold manufacturers: Anderson Greenwood AX3T VIS-4, Hoke GP831211F8YL, or equal.

2.06 CHEMICAL SEALS

A. Diaphragm Seals – Chemical Service:
   1. Seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Type 316L diaphragm unless otherwise specified. Wetted materials shall be submitted with proof of compatibility with the chemical service.
   2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type SG, Ashcroft Type 101, or equal.

B. Diaphragm Seals – Pressure Service 15 psig and Lower:
   1. Seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Elastomer diaphragm unless otherwise specified. Wetted materials shall be submitted to be compatible with the chemical service.
   2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type L, Ashcroft Type 741, or equal.

C. Diaphragm Seals – Chlorine or Sodium Hypochlorite Service:
   1. Seal shall be the diaphragm type with flushing connection, Hastelloy C, Monel, or Tantalum body and diaphragm unless otherwise specified.
   2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type SG, Type L for low pressure, Ashcroft Type 201, Type 741 for low pressure, or equal.

D. Diaphragm Seals – General:
   1. Provide ½" process and instrument connections. Provide 316 stainless steel reducer for instrument connection if required.
   2. Provide seal flushing connection Type 316 stainless steel interconnecting fitting, and flush valve per Paragraph 2.05 A.

E. Annular Seals:
   1. Seal shall be the in-line full stream captive sensing liquid type. Metallic wetted parts shall be Type 316 stainless steel. Flexible cylinder shall be Buna-N unless otherwise specified. Seals shall be rated 200 psig with not more than 5-inch water column (WC) hysteresis.
   2. Annular seal manufactures: OPW Engineered Systems/Ronningen-Petter Iso-Ring, Red Valve series 40, or equal.

F. Fill Fluid:
   1. Chemical seals and associated instruments shall be factory filled as follows:
      a. Instrument side of seal, capillary tubing, and instrument shall be evacuated to an absolute pressure of 1.0 Torr or less; filled; and sealed. Provide silicone oil fill fluid, halocarbon fill fluid for chlorine applications, unless otherwise recommended by the seal manufacturer.
      b. Chemical seal manufacture: Dow Corning DC200, Syltherm 800, or equal.

2.07 PURGE ASSEMBLIES

A. The purge assembly for air or water for flushing seals on sludge level measurement applications with a choice of Buna, Viton, Etylene Propylene O-Rings.

B. Air:
   1. Air purge assembly shall consist of a constant-differential relay, needle valve, check valve and 0.2 to 2.0 standard cubic feet per hour rotameter.
   2. Assembly manufacturer: ABB Purgemaster Series 10A6100, or equal.

C. Water:
   1. Water purge assembly shall consist of a strainer, constant-differential regulator, needle valve, check valve, and 20 to 200 cc/m rotameter. Provide 155 micron wye-type strainer.
   2. Strainer manufacturer: ASCO 8600A2, Crane, or equal.
   3. Assembly manufacturer: ABB Purgemaster Series 10A6100, or equal.

2.08 PRODUCT DATA

A. Applicable operating and maintenance information shall be provided in accordance with Section 01 33 00 as specified in Section 01 78 23.

PART 3 EXECUTION

3.01 INSTRUMENT AIR COMPRESSOR SYSTEM

A. Instrument air compressor system shall be installed and tested as specified in accordance with the manufacturer's instructions.

3.02 INSTRUMENT AIR PIPING

A. Instrument air piping shall be installed and tested as specified in Section 40 05 01. Taps to instrument air headers shall be made on the top of the header and provided with an isolation valve. An additional isolation valve and air set shall be provided at each instrument or panel requiring instrument air.

3.03 PNEUMATIC SIGNAL PIPING

A. Signal tubing shall be 1/4-inch copper unless otherwise specified. Tubing for control air to pneumatic actuators shall be 3/8-inch copper. Copper tubing shall be supported at intervals not to exceed 3 feet. Plastic tubing shall be used only where specifically specified and shall be continuously supported in trays or conduits provided as specified in Division 26. Tubing shall be run parallel or perpendicular to walls and structural members. Signal tubing shall follow building surfaces closely unless carried in trays or conduit. Tubing supported directly from concrete or concrete block surfaces shall be spaced at least 1/8 inch from said surface by the use of suitable clamp backs.

B. Bends shall be formed to uniform radii without flattening the tube. Ends of tubing shall be square-cut and cleaned before being inserted into fittings. Compression fittings shall be used for splices, turns, and connections near instruments. Bulkhead assemblies shall be provided for termination of field tubing on panels.

END OF SECTION

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SECTION 41 22 13.13

BRIDGE CRANES AND HOISTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope

1. This Section specifies an electrically operated bridge crane system complete with hoist, trolley, bridge, end trucks, and associated drive units and controls, for installation above the Clearwell (Area 70).

B. Type

1. Bridge crane shall be single girder top-running type mounted on individual drive end trucks designed to travel on ASCE runway rails, with underhung heavy-duty wire rope hoist and four-wheel trolley, equipped for electric lift and travel in both directions, with pendant control. All motor controller drives shall be adjustable speed type.

C. Equipment List

1. Equipment numbers are as follows:

Item	Equipment No.
Clearwell Bridge Crane	TBD

1.02 QUALITY ASSURANCE

A. Reference Standards

1. This Section incorporates by reference the latest revisions of the following documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). They are part of this Section. In case of conflict between the requirements of this Section and the listed documents, the Contractor shall point out the conflict to the Construction Manager; lacking a definitive answer otherwise, the requirements of the Contract Specifications shall prevail.

Reference	Title
AISC 360-16	Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings
AGMA	American Gear Manufacturers Association
ASME B30.10	Hooks
ASME B30.11	Monorails and Underhung Cranes
ASME B30.16	Overhead Hoists (Underhung)
ASME B30.17	Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoist)
ASME HST-4	Performance Standard for Electric Wire Rope Hoists
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A992	Standard Specification for Structural Steel Shapes
HMI	Hoist Manufacturer's Institute
CMAA 70	Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes

Reference	Title
CMAA 74	Specification for Top Running and Under Running Single Girder Electric Overhead Travelling Cranes Utilizing Under Running Trolley Hoist
NFPA 70	National Electric Code
ASME	American Society of Mechanical Engineers
CMAA	Crane Manufacturers Association of America
NEMA	National Electrical Manufacturers Association
OSHA	Occupational Safety and Health Administration
UL	Underwriters Laboratories

2. All equipment furnished under this Section shall comply in all respects with the requirements of OSHA, the standards of the Crane Manufacturer's Association of America (CMAA), the Hoist Manufacturer's Institute (HMI), ANSI/ASME HST-4 Performance Standards for Electric Wire Rope Hoists, and the National Electric Code (NFPA 70).

B. Unit Responsibility

1. The Contractor shall assign unit responsibility as specified in paragraph 43 05 11-1.02C to the bridge crane manufacturer for all equipment specified in this Section. The crane manufacturer is the unit responsibility manufacturer and has unit responsibility, as defined in Section 43 05 11, for the equipment specified in this Section. A completed and signed certificate of unit responsibility (Form 43 05 11-C, Section 01 99 90) shall be submitted as specified herein.

C. Factory Tests:

1. Manufacturer shall test the equipment in accordance with industry standards and federal regulations prior to shipment of the equipment. Crane, trolley, and hoist shall be completely assembled and no load run tested in the factory prior to shipment to the job site. Crane shall be disassembled to the least amount possible for shipment. Certification of the factory test results shall be provided as specified herein.

1.03 SUBMITTALS

A. Submittals shall comply with the requirements of Section 01 33 00. Submittals shall include the following information.

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.Completed Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts unit responsibility, in accordance with the requirements of this Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
2. Manufacturer's catalog data confirming rated capacity, equipment speeds, motor horsepower, electrical requirements, and component sizes and dimensions.
3. Bridge crane shop drawings showing physical details, dimensions of the bridge crane, and hoist equipment, details of construction for crane installation, and all information listed in this Section.
4. Runway beam design calculations. Loads to the building frame structure shall be provided in calculations. Calculations shall be stamped by a Utah registered structural engineer.
5. Anchor bolt calculations in accordance with Section 05 05 20.
6. Motor data.
7. Electrical diagrams and schematics.

1.04 PEFORMANCE REQUIREMENTS

A. Service Conditions

1. Bridge crane will be used to lift and maintain process equipment and related components for occasional maintenance.
2. Bridge crane will be installed above the Clearwell area (Area 70).
3. Environmental conditions are described in Section 01 11 80.
4. Electrical equipment, supports, and anchorage shall be designed and installed in accordance with the seismic design requirements specified in Section 01 73 24.
5. Except as noted, bridge crane shall be CMAA Class C. Bridge drive shall be CMAA Type A4. A heavy-duty hoist shall be suspended from the trolley.
6. Operating and dimensional data are specified in paragraph 41 22 13.13 1.04B.

7. Runway beams, rails, and bridge beams shall be as specified in this Section. Runway beams shall be complete with connections to the building structural system, splices, and crane stops, and shall be furnished by the crane manufacturer. Runway beam minimum size is shown on the Drawings. All beams shall be designed by a structural engineer registered in the State of Utah.
8. Hook approach distances shall be as shown on the Drawings.
9. Vertical Impact: An impact allowance shall be included in design calculations for trolleys, cranes and runways. The impact allowance shall be ½ percent of the rated load for each foot per minute of hoisting speed with a minimum allowance of 15 percent and a maximum allowance of 50 percent.
10. The Contractor shall examine the drawings for interferences and obstructions which might impose additional limitations upon the equipment.

B. Operating and Dimensional Data

Item	Value
Rated capacity, tons	7.5
Runway span, feet-inches	57'-8"
Runway length, feet-inches	80'-0"
Elevation of hook in highest position[a], minimum, feet	Per Drawings
Vertical lift, feet-inches	14'-0"
Speeds, fpm, infinitely variable[b]:	
Hoist	3.2 to 20.0
Bridge (travelling)	65 ft/min
Trolley (traversing)	100 ft/min
Motors[c]	Per CMAA and HMI Duty Class

Notes:

a. Actual hook position shall be the elevation required to lift and move blower equipment between clear space at roll up door and the installed locations.

b. Motors shall be controlled by adjustable frequency drives.

c. See Section 43 05 21.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Bridge cranes and hoists shall be KoneCranes, Stahl, R&M Materials Handling, American Equipment or equal, modified to provide the specified features. All products specified herein shall be provided by a single supplier.

2.02 MATERIALS

Component	Material
Runway beams	Steel, ASTM A992
Bridge beams and trolley	Steel, ASTM A992
Hoist gearing, trolley wheels, end truck wheels, hook	Steel
Wire rope	Steel

2.03 EQUIPMENT FEATURES

A. Runway Beams and Rails:

1. Runways shall be straight, parallel, and level and specially designed for this application. At full load, the runway beams shall be designed for a maximum deflection of 1/600 of span. Runway rails shall be selected for proper loading, and shall be ASCE 30# minimum. Runways shall be provided with bolted end stops.

B. Runway Supports:

1. Anchor bolts and clamps shall be provided to secure runway rails. Provide lateral bracing to walls for runways as recommended by manufacturer.

C. Bridge Beam:

1. The crane bridge assembly shall be a top-running, single girder bridge beam, electrically driven. The bridge beam shall be rigidly attached to end trucks and serve as the hoist runway. Permanent stops shall be provided to prevent trolley overrun. At full load, the bridge beam shall be designed for a maximum deflection of 1/800 of span.

D. End Trucks:

1. The bridge crane end trucks shall carry the rated load between the end truck wheels while the rated load is lifted at one end of the crane bridge. End truck wheel bases shall be 1/8 of the span. The crane and trucks shall contain diaphragm members welded to truck frames to maintain alignment and distribute truck loads on the inner and outer truck members.
2. An impact absorbing rubber bumper shall be mounted on each end of the end trucks. Rail sweeps shall be provided. Safety lugs shall be provided to limit drop of the end trucks to 1 inch or less in the event of wheel or axle failure.
3. Wheel bearings shall be roller type with life time lubrication, fitted with seals to exclude dust and moisture, and provided with a suitable reservoir of lubricant to eliminate the need for field lubrication.
4. Crane wheels shall be steel with flat tread surfaces hardened to 280 Brinell minimum. Wheel treads shall be smooth, true, and uniform within 0.01-inch tread diameter on all wheels. Wheel mounting shall be designed so that axles and wheels can be removed without disturbing other truck elements of their alignment.

E. Bridge Drive:

1. Bridge drive shall be CMAA Type A4. Bridge motors and drives shall be as specified in Paragraph 41 22 13.13-2.03H. The motors shall be provided with cushion start and controller for smooth travel and load control. The motors shall drive the bridge through gear reducers. Gear reducers shall be enclosed heavy-duty helical, or spur gear type, of a self-lubricating design, with anti-friction bearings. The drive shafts shall provide synchronous drive from the gear reduction units to both end trucks. Both motorized trolley wheels shall be driven simultaneously. Brakes shall be solenoid actuated. The crane drive shall include integrally mounted spring set electrically released AC or DC rectified disc brake.

F. Trolley:

1. The trolley shall be a four-wheel motorized assembly designed for under running hoist application. The trolley shall be framed by a structural shape welded into a stable assembly for proper wheel and bearing alignment. Trolley bumpers shall be provided. The trolley assembly shall be supported by trolley wheels with flat tread surfaces. The wheel tread shall be accurately machined to assure concentricity of axle and tread, and hardened to 280 Brinell minimum. Wheels shall be mounted on permanently lubricated anti-friction bearings. Bearings must have a minimum B-10 life of 10,000 hours. Trolley motor and drive shall be as specified in this Section. The motor shall be provided with cushion start and controller for smooth travel and load control. The motor shall drive the trolley through a gear reducer. Gear reducer shall be enclosed heavy-duty helical, or spur gear type, of a self-lubricating design, with anti-friction bearings. Brakes shall be solenoid actuated. Trolley drive shall include integrally mounted spring set electrically released AC or DC rectified disc brake.

G. Wire Rope Hoist:

1. The hoist shall be double reeved. The hoisting drum shall be grooved and designed for one layer of wire rope, with at least two (2) full turns of rope to remain on the drum at the lowest hook position. Hoist gearing shall be heat-treated hardened steel, running in an oil bath. Gear bearings shall be the oil-lubricated anti-friction type, and all bearings shall be designed for a Class M2 (20,000 hour) bearing life.
2. A gravity type and upper and lower geared limit switch shall be provided to assure safe operation and positive stopping under all conditions. The hoist shall be provided with a geared limit switch to automatically stop the motor and engage the hoist brake when the hook reaches either the upper or lower limit of travel. The hoist shall be provided with a load limiting device adjusted not to exceed 100 percent of rated capacity.
3. The load hook shall be mounted on ball thrust bearings to swivel without twisting the wire rope. The load hook shall be of the safety type, and the hook shall be of hardened steel equipped with a safety latch. Sheaves shall be properly guarded and shall be heavy pattern, deep flanged, and properly grooved. Sheaves shall be fitted with ball bearings and supported on fixed pins. Wire rope shall be improved plow steel with steel center complete with swaged fittings. Wire rope shall be grease impregnated. The rated capacity load divided by the number of parts of hoisting rope shall not exceed 20 percent of the published breaking strength of the rope.
4. Hoist motor brake shall be magnetically operated disc type or shoe type, mounted on the extended pinion shaft, and designed for a torque rating to 150 percent of the motor full load torque. Brake shall be equally effective in both directions of motor rotation and of sufficient size to stop motor and hold rated capacity load. Brake shall be set automatically when current is not flowing to the motor. A second “load brake” shall be included and applied automatically on lowering and require the motor to drive the load down. Brake shall be self-adjusting to allow for normal wear of the brake lining.
5. The Contractor shall furnish and install an identification plate on the hoist housing. The identification plate shall be of clearly legible permanent lettering giving the manufacturer's name, model number, rated capacity, and other essential information. In addition, the identification plate shall display the equipment number for the hoist that is identified herein.

H. Motors and Controllers:

1. Motors shall be 1750 rpm, TEFC, 30-minute-duty-cycle, rated for inverter duty, comply with CMAA No. 70 for AC Motors, and shall be suitable for the class and type of crane service specified herein. Hoist, trolley, and bridge motion shall be through adjustable frequency drive operation. All motors shall be provided with lifetime lubricated anti-friction bearings. The hoist motor bearings shall be designed for a Class M2 (20,000 hour) bearing life.
2. Controllers shall be capable of providing the control speed ranges specified in Paragraph 41 22 13.13-1.04B. Controllers shall provide soft start/soft stop (dynamic braking), acceleration control, phase loss protection, user programming, and ability to store and retrieve fault history.

I. Electrification and Controls:

1. All electrical and control equipment shall comply with the requirements of Division 26 and 40.
2. The crane manufacturer shall furnish and mount all electrical equipment on the crane including motors, adjustable frequency drives, controls, conduit, and wiring. Bridge conductors may be removed for shipment. All wiring on the crane shall be furnished, installed, and terminated by the crane manufacturer, as far as practical for shipment.
3. The crane manufacturer shall also provide a NEMA 4X main control panel and a NEMA 4X push-button pendant controller suspended from the trolley and capable of controlling all crane motions (hoist, bridge, and trolley). The main control panel shall include: service disconnect for mainline power feeding the panel; reversing controller for hoist, bridge, and trolley; thermal overload relays; control transformers; control relays; power terminal blocks and control terminal blocks all prewired, as required for a complete system and fully operational via a single 460V, 3-phase, 60 Hz power feed. A torque reel shall be supplied to allow easy adjustment of the pendant height for hoist use at anticipated elevations shown in 41 22 13.13-1.04B. Hoist, bridge, and trolley motion control shall be adjustable speed actuated from the pendant push button station suspended from the movable trolley. The pendant controller shall be equipped with an emergency stop pushbutton to disable all crane motions. All controls shall be clearly marked with etched or engraved nameplates.
4. The Contractor shall provide the power feed and a NEMA 4X lockable local main disconnect switch of suitable rating for the crane system and accessible from the operating floor.
5. Electrification of the bridge shall be by enclosed bus bar conductors. Conductor bars shall be stainless steel clad hard copper enclosed in insulation. Conductors shall be complete with all necessary insulation, supports, and appurtenances, and shall meet the NFPA 70 (NEC) requirements. Current collectors shall be the sliding noncopper bearing, carbon shoe type, with adjustable spring tension arms for contact between bus bars and controls. Collector mechanism components shall be aluminum, stainless steel, or other noncorrosive materials (excluding plastic). Electrification of the trolley and hoist shall be by flat insulated festooned cable supported in an enclosed track. Conductors shall be complete with all necessary insulation, supports and appurtenances as required. All other wiring of the crane shall be in rigid or flexible conduit and in accordance with National Electrical Code and complying with Fire Underwriters specifications. When a crane is shipped knocked down, the wiring shall terminate in approved terminal boxes and the wire ends shall be provided with permanent marking tags.

2.04 PAINTING

A. Contact wheel and rail surfaces shall not be coated. All other metal surfaces including the runway beams shall receive proper metal preparation and cleaning prior to application of protective coating. Finish color shall be alert orange except for trolley, which shall be a different color (e.g., blue) for good positioning contrast. Coating system shall be E-2 epoxy as specified in Section 09 90 00. Runway rails shall be coated after installation. All other components shall be factory coated, tested, and defects corrected prior to shipment. Field touch-up will be permitted for minor scratches but defective coatings shall be corrected in the shop. Manufacturer's standard epoxy finish is acceptable for the hoist.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Applicable operations and maintenance information as specified in Section 01 78 23.
   2. Factory test certification.
   3. Installation Certification Form 43 05 11-A specified in this Section.
   4. Training Certification Form 43 05 11-B specified in this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. The runway rails, bridge crane, trolley, and hoist shall be installed at the location shown and in accordance with the manufacturer's recommendations, within the tolerances recommended by CMAA, and under the supervision of the manufacturer's authorized field representative.

3.02 INSPECTION AND TESTING

A. After completion of the installation, the Contractor shall test all hoist and crane equipment under load in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets all applicable standards and specified performance requirements. Form 43 05 11-A shall be completed and submitted.

B. As a minimum, testing shall be by operating the equipment through a complete lift and lowering cycle and through a complete travel of the bridge and trolley to determine that the equipment performs smoothly and safely without failure.

C. The tests shall be carried out with the hoisting equipment loaded as near to the specified capacity as possible. Any defects shall be corrected or replaced immediately by the Contractor and at no expense to the Owner.

3.03 USE BY CONTRACTOR

A. Any hoist and crane equipment used by the Contractor shall be repaired, repainted and otherwise refurbished to like-new condition prior to its acceptance. After equipment refurbishment, the manufacturer's field representative shall re-inspect and re-test the crane unloaded, and certify in writing that the equipment meets all applicable standards and specified performance requirements. The certification shall be submitted. The Contractor assumes all responsibility for operation and maintenance until the equipment has been accepted.

3.04 WARRANTY

A. A written, one year warranty for equipment shall be provided. Warranty shall include parts and labor for any repair work.

3.05 TRAINING

A. Furnish the services of a factory trained representative for one (1) eight hour man-day for instruction of the Owner's personnel in the proper operation and maintenance of the equipment.

END OF SECTION

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SECTION 43 05 11

GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies general requirements which are applicable to all mechanical equipment. The Contractor is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of each individual equipment specification section.

B. Equipment Lists:

1. Equipment lists, presented in these specifications and as specified on the drawings, are included for the convenience of the Construction Manager and Contractor and are not complete listings of all equipment, devices and material required to be provided under this contract. The Contractor shall prepare his own material and equipment takeoff lists as necessary to meet the requirements of this project manual.

1.02 QUALITY ASSURANCE

A. Arrangement:

1. The arrangement of equipment shown on the drawings is based upon information available to the Owner at the time of design and is not intended to show exact dimensions conforming to a specific manufacturer. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from manufacturer to manufacturer. The contractor shall, in determining the cost of installation, include these differences as part of his bid proposal. Structural supports, foundations, connected piping, valves, and electrical conduit specified may have to be altered to accommodate the equipment actually provided. No additional payment shall be made for such revisions and alterations.

B. References:

1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ABMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA Std 11	Load Ratings and Fatigue Life for Roller Bearings
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)
ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI S2.19	Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications

C. Unit Responsibility:

1. The Contractor shall cause equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems as provided in the General Conditions of the Contract Documents.

D. The Contractor shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

E. Balance:

1. Unless specified otherwise, for all machines 10 HP and greater, all rotating elements in motors, pumps, blowers and centrifugal compressors shall be fully assembled, including coupling hubs, before being statically and dynamically balanced. All rotating elements shall be balanced to the following criteria:

$$U_{per} = 6.015\frac{GW}{N}$$

a. Where:

1) U_{per} = permissible imbalance, ounce-inches, maximum
2) G = Balance quality grade, millimeters per second
3) W = Weight of the balanced assembly, pounds mass
4) N = Maximum operational speed, rpm

2. Where specified, balancing reports, demonstrating compliance with this requirement, shall be submitted as product data. Equipment balance quality grade shall be *G* 2.5 (*G* = 2.5 mm/sec) or better in accordance with ANSI S2.19.

PART 2 PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.03 V-BELT ASSEMBLIES

A. Unless otherwise specified, V-belt assemblies shall be Dodge Dyna-V belts with matching Dyna-V sheaves and Dodge Taper-lock bushings, Wood's Ultra V-belts with matching Ultra-V sheaves and Wood's Sure-Grip bushings, or equal.

B. Sheaves and bushings shall be statically balanced. Additionally, sheaves and bushings which operate at a peripheral speed of more than 5500 feet per minute shall be dynamically balanced. Sheaves shall be separately mounted on their bushings by means of three pull-up grub or cap tightening screws. Bushings shall be key seated to the drive shaft.

C. Belts shall be selected for not less than 150 percent of rated driver horsepower and, where two sheaves sizes are specified, shall be capable of operating with either set of sheaves. Belts shall be of the antistatic type where explosion proof equipment is specified.

2.04 PUMP SHAFT SEALS

A. General:

1. Seals for water and wastewater pump shafts shall be either stuffing box or mechanical seals. For industrial wastewater service, or for fluids other than water or municipal wastewater, the recommendations of the seal manufacturer shall be followed for selection of appropriate seals. Unless specified otherwise, stuffing boxes and mechanical seals shall conform to the requirements set forth in this paragraph.

B. Mechanical Seals:

1. Unless otherwise specified in the detailed pump specifications, mechanical seals shall be split mechanical seals requiring no field assembly, other than assembly around the shaft and insertion into the pump. They shall be self-aligning, and self-centering, single seals. They shall be of a nondestructive (nonfretting) type requiring no wearing sleeve for the shaft. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area (no shaft sleeve). Where the detailed specifications call for cartridge instead of split seals, all other requirements of this paragraph apply.
2. Metal parts shall be Type 316 or 316L stainless steel. Springs shall be Hastelloy C, Elgiloy, or other Duplex SS selected for resistance to chloride attack. Rotary faces shall be silicon carbide or chrome oxide. Stationary faces shall be silicon carbide for solids bearing fluid service and carbon for clean water service. Elastomers shall be ethylene propylene or fluorocarbon. Mechanical seals shall be suitable for operation between full vacuum (0 psia) up to 200 percent of the maximum specified operating pressure, but in any event not less than 200 psig.
3. Seal chambers shall be provided with vented solids removal restriction bushings except for enclosed line shaft pumps where the seal barrier fluid is used for line shaft bearing lubrication. The bushing shall both control the amount of flushing water flow and restrict solids and gas accumulation from the seal face area.
4. Candidate seals include:
    a. Chesterton 442 seals provided with Chesterton/SpiralTrac solids removal restriction bushings Version N or D, as recommended by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
    b. AESSEAL RDSX seals with restriction bushing.
    c. John Crane 3710 seals with Type 24SL bushing.
5. Seals on pumps for contaminated water service (sludge, grit, wastewater, scum, reclaimed water, etc.) shall be drilled and tapped for connection of a clean water flushing supply.
6. Seals for all vertical pumps (whether column or volute type) shall be provided with a second flush connection. Vertical pumps shall have a vent valve attached to the mechanical seal to eliminate air from the seal chamber prior to pump start; start-up procedures shall include venting instructions; and for remotely started pumps, the vent system shall be automated. Where specified in the detailed specifications, permissive confirmation automatic vent systems shall be provided.

C. Shaft Packing:

1. Where shaft packing is specified, stuffing boxes shall be tapped to permit introduction of seal liquid and shall hold a minimum of five rows of packing. Stuffing boxes shall be face attached. Stuffing box and shaft shall be suitable for field installation, without machining or other modifications, of the mechanical seal specified in paragraph 2.04 Mechanical Seals for the applicable pump and operating conditions.
2. Unless otherwise specified, lantern rings shall be bronze or Teflon, packing shall be die-molded packing rings of non-asbestos material suitable for the intended service and as recommended by the manufacturer, and glands shall be bronze, two piece split construction. Lantern rings shall be of two-piece construction and shall be provided with tapped holes to facilitate removal. Lantern rings shall be drilled and tapped 1/4 NC-20. The impeller end of the packing on all but line shaft pumps with external source water lubricated bearings shall be fitted with a SpiralTrac, Version P packing protection system as manufactured by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
3. The section of each shaft or impeller hub that extends through or into the stuffing box shall be fitted with a replaceable stainless steel sleeve with a Brinell hardness of not less than 500. The sleeve shall be held to the shaft to prevent rotation and shall be gasketed to prevent leakage between the shaft and the sleeve. Minimum shaft sleeve thickness shall be 3/8 inch.

2.05 COUPLINGS

A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or equal, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.06 GUARDS

A. Exposed moving parts shall be provided with guards which meet all applicable OSHA requirements. Guards shall be fabricated of 14-gage steel, 1/2-13-15 expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts. Reinforced holes shall be provided. Lube fittings shall be extended through guards.

2.07 CAUTION SIGNS

A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "Caution Automatic Equipment May Start At Any Time". Signs shall be constructed of fiberglass material, minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size and pattern shall be as shown on the drawings. Signs shall be installed near guarded moving parts.

2.08 GAGE TAPS, TEST PLUGS AND GAGES

A. Gage taps shall be provided on the suction and discharge sides of pumps, blowers and compressors. Pressure and vacuum gages shall be provided where specified. Gage taps, test plugs, and gages shall be as specified in Division 40.

2.09 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.10 LUBRICANTS

A. The Contractor shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment (Section 01 45 20), the Contractor shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously. All lubricant shall be food grade.

2.11 ANCHOR BOLTS

A. Anchor bolts shall be designed for lateral forces for both pullout and shear in accordance with the provisions of Section 05 05 23. Unless otherwise stated in the individual equipment specifications, anchor bolt materials shall conform to the provisions of Section 05 05 23.

2.12 SPARE PARTS

A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 GENERAL

1. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION

SECTION 43 05 13

RIGID EQUIPMENT MOUNTS

PART 1 GENERAL

1.01 SUMMARY

1. Section includes: This Section specifies requirements for rigid equipment mounts. Rigid equipment mounts consist of equipment pads, equipment anchors, and mounting plates (baseplates, soleplates, or fabricated steel frames) set in grout.
2. Conform to the requirements specified in the Equipment Mounting Schedule (Part 4 of this Section) or equipment mounting configuration requirements specified in individual equipment specifications . Where equipment mounting requirements are not specifically identified, the default mounting configuration for equipment consists of Pad Anchored Equipment Pads per Standard Detail D01007 with adhesive dowels anchoring the equipment pad to the foundation, equipment and driver mounted on a common mounting plate, mounting plate leveled within 0.005 inch/foot, equipment anchored to the equipment pad with cast-in-place equipment anchors per Standard Detail D01002, equipment anchor sleeve length is 10 times the bolt diameter, and the mounting plate is grouted in position using non-shrink grout.
3. If a conflict exists between this Section and requirements of individual equipment manufacturers, the more restrictive requirements shall prevail.
4. Requirements for non-rigid equipment mounts (vibration isolation systems) are specified in the associated equipment specification. Furnish rigid equipment mounts conforming to the requirements of this Section for the equipment pad and other equipment mounting components supporting the vibration isolation system.

1.02 RELATED SECTIONS

A. This Section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 61 45 – Area Exposure Designations
   2. Section 01 73 23 - Structural Design and Anchorage Requirements for Nonstructural Components and Non-Building Structures
   3. Section 01 99 90 - Reference Forms
   4. Section 03 60 00 – Grouting
   5. Section 05 05 20 – Anchor Bolts
   6. Section 09 90 00 – Painting and Coating
   7. Section 43 05 11 – General Requirements for Equipment
   8. Section 43 05 14 – Machine Alignment
   9. Section 43 05 17 – Vibration and Critical Speed Limitations

1.03 REFERENCES

A. This Section contains references to the following documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section prevail.

Reference	Title
ACI 318, Appendix D	Building Code and Commentary, Anchorage to Concrete
HI 14.3	Rotodynamic Pumps –for Design and Application
HI 14.4	Rotodynamic Pumps –for Installation, Operation and Maintenance
API RECOMMENDED PRACTICE 686	Recommended Practices for Machinery Installation and Installation Design
ASCE 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures
ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ASTM E329	Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F1554	Anchor Bolts, Steel, 36, 55 and 105 ksi Yield Strength
MIL-PRF-907E	Anti-Seize Thread Compound, High Temperature
SSPC	Society for Protective Coatings Specifications, Vol. 2
IBC	International Building Code (including local amendments)

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Baseplate: A mounting plate configured with a top plate and a perimeter edge of the mounting plate that is below the top plate. Baseplates have a cavity between the top plate and a horizontal plane at the bottom edge of the perimeter of the mounting plate.
   2. Soleplate: A machined or pre-formed mounting plate with a uniform horizontal surface across the entire underside of the mounting plate, excepting shear lugs/keys, grout pour holes, vent holes, and attachment hardware (nuts, bolts, tapped holes, etc.). Soleplates have a top plate but lack the perimeter bottom edge that extends below the underside of the top plate that is a defining feature of baseplates.
   3. Fabricated Steel Frame: An equipment mounting plate constructed of rolled steel shapes and plates welded into a frame. Fabricated steel frames do not have top plates.
   4. Equipment Pad: Concrete foundation (block or slab) supporting and elevating mounting plates above the supporting structural floor slab or local grade.
   5. Mounting Pads: Milled/machined areas of baseplates, soleplates, and fabricated steel frames where the feet or mounting surfaces of mounted equipment and drivers are bolted to the baseplate, soleplate, or fabricated steel frame.
   6. Leveling Blocks: Steel blocks temporarily placed under baseplates, soleplates, or fabricated steel frames at leveling positions (at equipment anchors) for the purpose of leveling baseplates, soleplates, or fabricated steel frames prior to grouting.
   7. Shims: Thin stainless steel plates of uniform thickness used for fine adjustment of level. Shims are used on top of leveling blocks for mounting plate leveling or used between equipment drivers and baseplates, soleplates, or fabricated steel frames for equipment alignment.

8. Wedges: Pairs of uniformly tapered metal blocks that are stacked with the tapered surfaces reversed (relative to the other wedge) so that the top and bottom surfaces of the wedges are parallel. Wedges are used between equipment pads and baseplates, soleplates, or fabricated steel frames for the purpose of leveling mounting plates.
9. Mounting Stud: Threaded rod or bolts anchored to baseplates, soleplates, or fabricated steel frames for the purpose of mounting equipment or ancillary devices onto baseplates, soleplates, or fabricated steel frames.
10. Reinforcement Dowels or Reinforcement Hooks: Steel reinforcement rods embedded in concrete, across a cold joint, for the purpose of transferring loads or force across the joint.
11. Leveling Position: A location on the top of a concrete equipment pad where leveling tools and equipment will be temporarily installed or used for the purpose of leveling baseplates, soleplates, and fabricated steel frames prior to grouting.
12. Grout Manufacturer: Refers to the manufacturer of the grout product used for installation of rigid equipment mounts.
13. Grout Manufacturer's Technical Representative(s): Refers to the technical representative(s) of the Grout Manufacturer. The Grout Manufacturer's Technical Representative shall not be an employee of the Contractor.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meetings:
   1. Conduct a pre-installation meeting with the Construction Manager's representative prior to installation of equipment mounts.
   2. Schedule a pre-installation meeting for the equipment mounts associated with each system or group of identical equipment items.
   3. Where equipment anchors are cast in the floor slab or foundation, schedule the pre-installation meeting prior to pouring the floor slab or foundation.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, including addendum updates, (referenced sections need not be included for this Section) with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from specification requirements. Check marks denote full compliance with a paragraph as a whole. Underline each deviation and denote with a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. Mark copies of this Section with the specification number and equipment number for inclusion (filing) with submittal materials furnished for individual equipment specifications.
   3. Name, employer, and a copy of the employee's Qualified Millwright card or other equivalent certificate of journeyman qualifications for millwrights who will install rigid equipment mounts, as specified in paragraph 3.02, Leveling.
   4. Certificates or other documentation issued by the epoxy grout manufacturer that demonstrates that the grout manufacturer's technical representative has been factory trained on installation of epoxy grout for equipment mounts, as specified in paragraph 1.07 Quality Control by Contractor.

5. List of Contractor's equipment installation staff that have completed epoxy grout manufacturer's grout installation training specified in paragraph 3.03, Manufacturer's Services.
6. Shop drawings for equipment pads, equipment anchors, and baseplate, soleplate or fabricated steel frame depict size and location of equipment pads and reinforcement; equipment drains; equipment anchor, size, location, and projection; expansion joint locations; grout formwork; elevation of top of grout and grout thickness; elevation of top of baseplate, soleplate, or mounting block; size and location of electrical conduits; and any other equipment mounting features embedded in equipment pads. Shop drawings for equipment pads, equipment anchors, and baseplate, soleplate, or fabricated steel frames to be numbered and marked (specification number and equipment number) for inclusion (filing) with the associated equipment submittal requirements.

B. Informational Submittals:
1. Procedures: Section 01 33 00
2. Submit equipment anchor calculations demonstrating compliance with paragraph 2.04, Equipment Anchor Design. Submit equipment anchor calculations with submittal information specified in the associated equipment specification.
3. Results of grout strength tests, as specified in paragraph 3.02, Grouting.
4. Completed Rigid Equipment Mount Installation Inspection Checklist Forms (43 05 13-A), as specified in paragraph 3.03, Manufacturer's Services.

1.07 QUALITY ASSURANCE

A. Quality Control By Contractor:
1. Except where union rules require installation by another trade, all machinery to be mounted and leveled by journeyman millwrights.
2. Epoxy grout installation performed by employees that have completed the epoxy grout manufacturer's grout installation training specified in this Section.
3. Provide the services of an independent testing laboratory that complies with the requirements of ASTM E329. Testing laboratory to sample and test materials installed as part of rigid equipment mounts specified in this Section. Testing laboratory services costs borne by the Contractor.
4. Where epoxy grout is specified for bedding mounting plates, furnish the services of a grout manufacturer's technical representative who has been factory trained by the grout manufacturer. The grout manufacturer's technical representative performs training and quality control for epoxy grout installation for rigid equipment mounts as specified in paragraph 3.03, Manufacturer's Services.

B. Special Inspection for Equipment Anchors:
1. Equipment anchors shall comply with special inspection requirements specified in Section 05 05 20.

PART 2 PRODUCTS

2.01 GENERAL

A. Configure rigid equipment mounts as specified in the Equipment Mounting Schedule (See Part 4 of this specification) or as specified in individual equipment specifications. Equipment mounting configuration requirements in individual equipment specifications govern over configuration requirements specified in the Equipment Mounting Schedule. In the absence of equipment mounting configuration requirements in either of these locations, mount equipment per the default requirements specified in paragraph 1.01.

B. Pumps installed in accordance with this Section, HI 14.3, and HI 14.4.

2.02 MATERIALS FOR EQUIPMENT MOUNTING

A. Equipment pads: Reinforced concrete as specified in Standard Details D01006, D01007, D01008, and D01009.

B. Mounting Plates: Cast iron, cast steel, plate steel, fabricated steel frame, polymer concrete, or FRP as specified in the equipment specification.

C. Grout type for equipment mounting as specified in the Equipment Mounting Schedule or in individual equipment specification.

1. Epoxy Grout for Equipment Mounting: Where epoxy grout is specified in the Equipment Mounting Schedule or in individual equipment specifications, provide Epoxy Grout for Equipment Mounting as specified in Section 03 60 00. Where the term epoxy grout is used in the context of details and specifications for equipment mounting it means Epoxy Grout for Equipment Mounting as specified in Section 03 60 00.
2. Cementitious Nonshrink Grout: Where non-shrink grout is specified in the Equipment Mounting Schedule or in individual equipment specifications, Cementitious Non-shrink Grout, specified in Section 03 60 00, may be used for setting bearing surfaces of baseplates, soleplates, or fabricated steel frames. Where the term non-shrink grout or cementitious grout is used in the context of details and specifications for equipment mounting it means Cementitious Non-shrink Grout as specified in Section 03 60 00.

D. Equipment anchors: Materials per the following table and per the area exposure condition where the equipment is installed. Section 01 61 45 specifies area exposure conditions.

Area Exposure	Equipment Anchor Materials
Indoor, Dry	Carbon Steel, ASTM F1554, Grade 36, weldable per S1 for threaded rod
Indoor, Wet	Galvanized Carbon Steel, ASTM F1554, Grade 36, weldable per S1 for threaded rod
Outdoor	304 Stainless, ASTM F593, Cond. CW
Submerged, Immersed	316 Stainless, ASTM F593, Cond. CW
Process Corrosive	316 Stainless, ASTM F593, Cond. CW
Chemical Corrosive	316 Stainless, ASTM F593, Cond. CW

E. Anchor sleeves: Flexible polyurethane foam, steel cylinder/tubes, or corrugated/ribbed plastic sleeves.

F. Epoxy Primer: High-strength, lead free, chrome free, rust inhibiting two-component epoxy primer specifically designed for use on metal substrates and in conjunction with epoxy grout. Bond strength to sandblasted metal not less than 1500 psi.
    a. ITW Performance Polymer MS-7CZ primer
    b. Approved equal.

G. Anti-seize/Anti-galling compound: Molybdenum disulfide and graphite combination in aluminum complex base grease conforming to MIL-PRF-907E.
    a. Jet Lube 550 by Jet Lube, Inc.
    b. E-Z Break by LA-CO
    c. or approved equal.

2.03 EQUIPMENT PADS

A. Minimum dimensions for equipment pads are shown on structural drawings where a minimum equipment pad mass is required for vibration dampening/control.

B. Equipment Pad Drainage:
    1. Furnish equipment pads with 2-inch drains.
    2. Locate equipment pad drains at drainage outlets from equipment or mounting plates
    3. Route equipment drainage outlets or mounting plate drainage outlets to equipment pad drains
    4. Route equipment pad drains to the floor drainage collection system.
    5. Drainage piping for equipment pads shall be routed below the finished floor elevation.
    6. Exposed drain lines mounted on the floor are not acceptable.

2.04 EQUIPMENT ANCHORS:

A. Equipment Anchors:
    1. All thread rod with heavy hex welded nuts, heavy hex bolts, post-installed anchors (wedge, sleeve, undercut, expansion, and adhesive anchors), or adjustable canister anchors as specified in the Equipment Mounting Schedule or in individual equipment specifications.
    2. Bolt length as required for the specified embedment and sleeve length. Reduce equipment anchor sleeve length as necessary to fit within finished height of equipment pad if equipment pad height is insufficient to provide specified equipment anchor sleeve length. Unified Coarse Thread Series per ASME B1.1.
    3. Post-installed anchors (wedge, sleeve, undercut, expansion, and adhesive anchors) conforming to the requirements of Section 05 05 20.
    4. Adjustable canister anchors consist of cast-in-place pre-manufactured adjustable anchor inserts. Provide a minimum of 6 inches of vertical bolt height adjustment and lateral adjustment of the anchor bolt while maintaining the anchor bolt in a true vertical orientation.
        a. Jakebolts as manufactured by Unisorb
        b. Heavy Duty Adjustable Anchors as manufactured by Deco
        c. Rowan Adjustable Canister Anchor Bolt
        d. or approved equal.

B. Equipment Anchor Design:
   1. Size (diameter) of anchors for clamping/fastening mounting plates to equipment pads determined by the equipment manufacturer.
   2. Comply with Utah Governing Building Code for equipment anchor size, embedment, and edge distance. Provide equipment anchors that are sufficient to resist the maximum lateral and vertical forces specified in Section 01 73 23.
   3. Resistance to lateral (horizontal) loads based on the static friction between the mounting plate and its supporting grout pad. Include the clamping force applied by equipment anchors and the weight of the equipment for calculating static friction resistance to lateral loads. Do not include lateral (shear) loading on equipment anchors or adhesion between mounting plates and supporting grout in lateral loading resistance calculations.
   4. Furnish equipment anchor calculation submittals for all rotating equipment including (but not limited to) pumps, flocculators, and generators.
   5. Equipment anchor calculations sealed by a registered structural or civil engineer licensed in the State of Utah.

C. Equipment Anchor Tension:
   1. Unless alternate bolt torque/tension requirements are specified by the equipment manufacturer, tighten equipment anchors to provide a final clamping force that produces a tensile stress of 15,000 psi in each equipment anchor. Tighten adjustable canister anchors to the manufacturer's maximum safe working load. Tighten post-installed anchors to manufacturer's recommendations.
   2. Bolt torque values required to produce the specified bolt tension based on well lubricated plain finish national coarse thread bolts are presented in the following table. Revise bolt torque values per equipment manufacturer's recommendations for alternate thread patterns, thread lubrication, bolt material, or bolt finish.

Bolt Diam. (in)	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Final bolt torque for 15,000 psi bolt stress (ft*lbs)	8	15	30	50	80	125	180	250	400

   3. Prior to leveling and grouting mounting plates, pull test grouted equipment anchors (standard detail D01003) to the values specified in the following table.

Anchor Diam. (in)	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Pull test load (kips)	2.1	3.8	6.1	9.1	13	17	22	28	43

D. Anchor Sleeves:
   1. Provide sleeves for equipment anchors as specified in the Equipment Mounting Schedule or in individual equipment specifications.
   2. Adjust equipment anchor length/embedment depth shown in Standard Detail D01002 and Standard Detail D01003 if sleeves are not required.
   3. Sleeves may be installed at the Contractor's option if not specified in the Equipment Mounting Schedule or in individual equipment specifications provided they do not interfere with specified embedment lengths.

4. Fill steel cylinders/tubes and ribbed plastic sleeves with a flexible room temperature vulcanizing (RTV) sealant prior to embedment/installation.

2.05 MOUNTING PLATES

A. General:

1. Round edges of surfaces of baseplates, soleplates, and fabricated steel frames that bear on grout to a radius of not less than 0.25 inch.
2. Round perimeter corners of baseplates, soleplates, or fabricated steel frames to a radius of not less than 2.0 inches to avoid producing stress risers on the grouted foundation.
3. Provide grout pouring holes (minimum 4 inches in diameter for epoxy grout, minimum 2.5 inches in diameter for cementitious non-shrink grout) and air release holes in all baseplates and soleplates.
4. Provide grout relief or vent holes (minimum 1 inch in diameter) in all baseplates and soleplates.
5. Drill mounting holes for equipment anchors through baseplates, soleplates, and fabricated steel frames. Open slots or burned out holes for equipment anchors are not permitted.
6. Provide acorn nuts welded to the underside of the baseplate or soleplate or nuts welded to the underside of the baseplate or soleplate and plugged with cork, plastic plugs or grease where terminations to baseplates and soleplates are required.
7. Where fasteners terminate only into the baseplate, soleplate, or fabricated steel frame, threaded lengths (tapped or embedded in mounting plates) shall be not less than the bolt diameter.
8. Where baseplates, soleplates, or fabricated steel frames are leveled using jackscrews, tap jackscrew threads in thickened pads or otherwise in sufficient metal to provide ease in adjusting level.
9. Mill mounting pads and/or mounting surfaces of baseplates, soleplates, and fabricated steel frames flat and coplanar within 0.0005 inch per foot in all directions after all welding and stress relieving.
10. Pre-grout baseplates prior to milling.
11. Baseplates, soleplates, and fabricated steel frames provide common support for the equipment and driver (and flywheel, if one is specified).
12. For equipment with drivers 20 horsepower and greater, provide transverse alignment (horizontal) positioning jackscrews for alignment of equipment drivers on horizontal surfaces of baseplates, soleplates, and fabricated steel frames.
13. Provide alignment/positioning jackscrews in perpendicular directions in a horizontal plane at the mounting position for each corner or foot of the equipment driver. (Additional jackscrews provided for transverse alignment of the flywheel, if flywheels are specified in the equipment specification.)
14. Where specified in individual equipment specifications; baseplates, soleplates, and fabricated steel frames fitted with RK Fixators as manufactured by Unisorb, or approved equal.
    a. Fixators installed at mounting surfaces for drivers.
    b. Fixators consist of a three-piece wedge leveling adjustment device incorporating a spherical washer assembly to provide true level height adjustment at each mounting surface for the equipment driver.

B. Fabricated Steel Frames:
   1. Fabricated steel frames consist of structural steel shapes welded to form mounting plates.
   2. Fabricated steel frames to be rectangular in shape, excepting fabricated steel frames for centrifugal refrigeration machines and pumps which may be T- or L-shaped to accommodate the equipment driver and accessories.
   3. Fabricated steel frames for split case pumps include supports for suction and discharge elbows, if required by the specified configuration.
   4. Perimeter members consist of I-beams or C-channel with a minimum depth equal to 1/10 of the longest dimension of the fabricated steel frame. Beam depth need not exceed 14 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
   5. Fabricated steel frames furnished with thickened steel mounting pads welded to the fabricated steel frame for bolting equipment to the mounting plate.
   6. Sandblast surfaces of fabricated steel frames in contact with grout to white metal per SSPC SP-5.
   7. Apply a high-strength epoxy primer as specified in paragraph 2.02 within 8 hours of sandblasting the fabricated steel frame.

C. Baseplates:
   1. Baseplates may be welded steel, cast steel, or cast iron with thickened mounting pads for bolting equipment to the baseplate.
   2. Provide internal stiffeners on all cast and fabricated baseplates. Stiffeners designed to allow free flow of grout from one section of the baseplate to another.
   3. Provide a minimum 2 inches high by 6 inches wide opening in cross bracing and stiffeners for grout flow between sections of the baseplate.
   4. All welds continuous and free from skips, blowholes, laps and pockets.
   5. Pre-grout baseplates at the factory after all welding has been completed and prior to machining the mounting pads on the baseplate. Pre-grout baseplates in the field if they have not been pre-grouted at the factory. Remove the equipment from the baseplate, invert the baseplate, and pre-grout as specified in this Section.
   6. Prior to pre-grouting, sandblast the underside of baseplates to white metal per SSPC SP-5.
   7. Complete pre-grouting within 8 hours of sandblasting.
   8. Fill the underside of the baseplate to the bottom edges of the baseplate.
   9. Seal cast iron baseplates to prevent surface bleeding prior to shipment to the project site.

D. Plate Steel Soleplates:
   1. Not less than 1.0 inch thick for equipment with drivers greater than 30 horsepower.
   2. Furnished with grout keys/lugs or stiffeners on the underside of the soleplate.
   3. Flat uniform horizontal surface on underside of plate steel soleplates, excepting grout keys, grout pour holes, vent holes, and attachment hardware (nuts, bolts, tapped holes, etc.).
   4. Prior to milling the mounting pads for equipment or mounting surfaces, scribe the words “THIS SIDE DOWN”, using welding rod material, on the underside of plate steel soleplates , .

5. Plate steel soleplates without grout pouring holes are acceptable provided that no dimension of the soleplate (width or length) exceeds 18 inches.
6. Sandblast surfaces of plate steel soleplates in contact with grout to white metal per SSPC-SP-5, prior to shipment to the project site.
7. Apply a high-strength epoxy primer as specified in paragraph 2.02 within 8 hours of sandblasting the underside of plate steel soleplates.
8. Where equipment is fabricated or cast with feet or mounting surfaces that are not fastened to a common baseplate or soleplate, as in dry-pit bottom-suction pumps, the equipment may be supported on individual concrete piers or equipment pads in lieu of mounting on a common equipment pad and soleplate. In such instances, support the equipment at the feet or mounting surfaces on individual plate steel soleplates. Level individual plate steel soleplates and grout into place on the individual piers or equipment pads as specified in this Section. Where multiple soleplates are installed to support one piece of equipment, soleplates shall be coplanar within 0.002 inch/foot.

E. Polymer Concrete Soleplates:
1. Pre-cast soleplates consisting of polymer concrete with stainless steel inserts for equipment mounting.
2. Mounting surfaces shall be coplanar within 0.002 inch/foot.
3. Furnished with a uniform horizontal surface over the entire underside of the mounting plate, excepting grout keys, grout pour holes and vent holes.
   a. PoxyBase as manufactured by Basetek
   b. Chembase as manufactured by Goulds
   c. Approved equal.

F. Corrosion Resistant FRP Baseplates:
1. Pre-formed fiber reinforced plastic fabrications.
2. Product of the manufacturer of the equipment that is mounted on the baseplate.

PART 3 EXECUTION

3.01 PREPARATION

A. Concrete Equipment Pad Preparation:
1. Roughen the top of the equipment pad after the concrete has reached its 28-day compressive strength.
2. Remove all laitance and defective or weak concrete.
3. Roughen surface profile to 0.25 inch amplitude, minimum.
4. Expose broken aggregate without dislodging unbroken aggregate from the cement matrix and without fracturing concrete and aggregate below the concrete surface.
5. Roughen using a light-duty (15 pounds or less), hand-held chipper with a chisel type tool.
6. Abrasive blast, bush-hammer, jack hammers with sharp chisels, heavy chipping tools, or needle gun preparation of concrete surfaces to be grouted are not acceptable.
7. Demonstrate removal of defective or weak concrete to the Construction Manager prior to leveling.

8. Chip the surface of the concrete such that the final elevation of the equipment pad provides the grout manufacturer's recommended thickness between the surface of the equipment pad and the lower baseplate flange, underside of the soleplate, or underside of the fabricated steel frame.
9. Remove all dust, dirt, chips, oil, water, and any other contaminants and protect the surface with plastic sheeting until grout is installed.
10. Protect concrete equipment pad surfaces that have been finished smooth and level for use as leveling positions. Protect from damage during chipping activities. Alternatively, leveling positions may be restored on chipped surfaces. Restore leveling positions by installing leveling blocks or leveling plates for jackscrews on a high compressive strength epoxy putty (Philadelphia Resins, Phillybond Blue 6A, or equal). Leveling blocks and leveling plates installed level on the epoxy putty.

B. Grout Form Construction:
1. Design forms for a minimum of 6 inches hydrostatic head above the final elevation of the grout and manufacturer's recommendations for form edge clearance for intended pour scheme, but not less than two inches.
2. Install grout expansion joints at 4 to 6 foot intervals, perpendicular to the centerline of baseplates. Design expansion joints in accordance with the grout manufacturer's written instructions.
3. Coat forms with three coats of paste wax on all areas of the forms that will be in contact with the grout.
4. Wax forms before assembly.
5. Prevent accidental application of wax to surfaces where the grout is to bond.
6. Remove any foreign material, such as oil, sand, water, wax, grease, etc., from concrete surfaces that will contact grout before forms are installed.
7. Forms must be liquid tight. Seal any open spaces or cracks in forms, or at the joint between forms and the foundation using sealant, putty, or caulking compound.
8. Chamfer vertical and horizontal edges of the grout with 45-degree chamfers as specified in equipment pad details. Locate 45-degree perimeter chamfer strips at the final elevation of the grout.
9. Match chamfers in concrete portions of the equipment pad.
10. Install block outs at all leveling positions to allow removal of leveling equipment and leveling nuts to be backed off after the grout has cured.
11. Coat jackscrews with a light oil or other acceptable bond-breaking compound prior to grouting.
12. Seal equipment anchor sleeves to protect the sleeved length of the anchor from contact with grout.
13. Wrap exposed portions of equipment anchors with duct tape to protect them from grout splatter and to prevent bonding to grout.

C. Mounting Plate Preparation:
1. Roughen the underside of soleplates and fabricated steel frames and wipe with a residue-free solvent as recommended by the epoxy primer manufacturer before placement of the baseplate, soleplate, or fabricated steel frames on the equipment pad for leveling. Roughen surfaces of mounting plates that will be in contact with grout by power tool cleaning. Cleaning performed by power wire brushing, power sanding, power grinding, power tool chipping or power tool descaling. Impart a minimum profile of 1.0 mil.

2. Prior to placement on the equipment pad for leveling, roughen exposed grout surfaces of pre-grouted baseplates and wipe with a residue-free solvent as recommended by the manufacturer of the epoxy grout used for pre-grouting.
3. Prepare the underside of corrosion-resistant FRP baseplates and polymer concrete baseplates per the baseplate manufacturer's recommendations and prior to placement of the baseplate on the equipment pad for leveling.
4. Grouting for installation of mounting plates on equipment pads completed prior to connecting any field piping or electrical and instrumentation systems.
5. Unless the Construction Manager accepts an alternate installation procedure in writing, baseplates, soleplates, and fabricated steel frames leveled and grouted with the equipment removed.

3.02 INSTALLATION

A. Leveling:
1. Except where union rules require installation by another trade, all equipment and machinery mounted and leveled by a Qualified Millwright.
2. Use precision surveying equipment for leveling.
3. Machinists' spirit levels will not be permitted for leveling purposes for any baseplate, soleplate, or fabricated steel frame with a plan dimension greater than 4 feet.
4. Baseplates, soleplates, and fabricated steel frames leveled to the tolerance specified in the Equipment Mounting Schedule, in the individual equipment specification, or as otherwise required by the equipment manufacturer, if more stringent.
5. Apply an anti-seize or anti-galling compound, specified in paragraph 2.02, to all equipment anchor threads prior to beginning baseplate, soleplate, or fabricated steel frame leveling.
6. Level all baseplates, soleplates, and fabricated steel frames against steel surfaces (jackscrew plates, leveling blocks, leveling nuts, support plates, or other steel surfaces). Use of other materials for leveling purposes is strictly and specifically prohibited.
7. Use stainless steel leveling blocks and shims, steel wedges, or jackscrews bearing on leveling plates.
8. Leveling nuts may be used for leveling baseplates, soleplates, and fabricated steel frames weighing less than 200 pounds (inclusive of the weight of the equipment if leveled with the equipment on the mounting plate).
9. Leveling blocks shall be stainless steel, 4 inches square and 1.5 inches thick with an open-ended slot terminating in the center for the equipment anchor.
10. Machine leveling blocks flat on all horizontal surfaces and place under the baseplate or soleplate at each equipment anchor.
11. Provide pre-cut stainless steel shims, slotted for removal after grouting. Coat leveling blocks and shims with a light oil just prior to beginning the leveling and grouting work. Place shims so the tabs on the shims are easily accessible.
12. Clamp baseplates, soleplates, or fabricated steel frames in position (after leveling) by installing the equipment anchor nuts and washers.
13. Apply bolt tension to fix the position of mounting plates during grouting (30 to 60 percent of the final clamping force applied to clamp the mounting plate to the equipment pad).
14. Prior to grouting, verify that the correct level and position of the baseplate, soleplate, or fabricated steel frame has been maintained after clamping it to the equipment pad.

B. Grouting:
   1. Adjust ambient temperature to maintain mounting plate, foundation, and grout temperatures to grout manufacturer's recommended temperature.
   2. Mix grout for equipment mounting in accordance with the grout manufacturer's written recommendations.
   3. Place epoxy grout using a method that avoids air entrapment.
   4. Place grout at one end of the baseplate or soleplate and work grout toward the opposite end to force the air out from beneath the baseplate or soleplate.
   5. Pour grout through a head box into grout pouring holes.
   6. When the head box is moved to the next grout hole, place a 6 inch standpipe over the grout hole and fill with grout.
   7. Pour grout to the top of the lower flange of the perimeter I-beams or C-channel of fabricated steel frames.
   8. Pour grout at least 0.125 inch but not more than 0.5 inch above the bottom or underside of the perimeter edge of a baseplate or soleplate.
   9. Use of vibrating tools and/or jarring (rapping or tapping) forms to facilitate grout flow is not permitted during placement of epoxy grout.
   10. Never allow the grout in the head box to fall below the top of the baseplate or soleplate once the grout has made contact with the baseplate or soleplate.
   11. Grout placement applied in one continuous pour, until all portions of the space beneath the baseplate, soleplate, or fabricated steel frame have been filled.
   12. Prepare subsequent batches of grout prior to depleting the preceding batch.
   13. Maintain grout height in standpipes after the space under the baseplate, soleplate, or fabricated steel frame has been filled.
   14. When the grout has started to take an initial set (typically this is determined by a noticeable increase in temperature and no flow of grout at the vent holes) remove the standpipes and clean excess grout from all surfaces.
   15. Check for leaks throughout grout pours. Repair leaks immediately to prevent formation of voids.
   16. Check baseplate, soleplate, or fabricated steel frame level and elevation before the grout sets.
   17. Cure grout in accordance with the grout manufacturer's written instructions.
   18. Collect at least one grout sample from each grout pour. Where specified in the individual equipment specifications, collect a grout sample from the grout pour for each equipment pad.
       a. Place samples in a cylinder of sufficient size to yield three 2-inch cubes as test samples.
       b. Label samples with project name, date, time, the equipment number, and ambient temperature at the time of placement.
       c. Place samples next to the foundation of the equipment being grouted and cure for 48 hours.
       d. Test grout samples in accordance with the grout manufacturer's recommendations.
       e. Grout samples tested by the independent testing laboratory specified in paragraph 1.07 Quality Control by Contractor.
       f. Report test results directly to the Construction Manager.

C. Completion:
   1. Upon acceptance by the Construction Manager and the equipment manufacturer's representative and after the grout has reached sufficient strength, remove grout forms and block outs at leveling positions. Remove leveling blocks and shims or wedges and support plates. Back off leveling nuts and jack screws to allow the grout to fully support the baseplate, mounting block, or soleplate. Take care not to damage the grout during removal of extended shimming material or leveling equipment and tools.
   2. Tighten equipment anchor nuts using calibrated indicating torque wrenches, to develop the full bolt tension specified in paragraph 2.04 Equipment Anchor Tension.
   3. Tighten equipment anchor nuts in increments of not more than 25 percent of the final torque value in an alternating pattern to avoid stress concentration on the grout surface. After tightening equipment anchor nuts to final values, apply additional wax, grease, or mastic to all exposed portions of the equipment anchor beneath the baseplate, soleplate, or mounting block.
   4. After applying additional wax or mastic to exposed portions of equipment anchors and tightening to final torque values, fill and point block outs (pockets) for access to leveling nuts, leveling blocks, shims, or wedges with the grout material installed under baseplates, soleplates, or fabricated steel frames. Remove jackscrews and fill holes in the baseplate, soleplate, or fabricated steel frame with a flexible sealant (silicone rubber) or a short cap screw.
   5. Check for baseplate, soleplate, or fabricated steel frame movement (soft foot) by individually loosening and re-tightening each equipment anchor. Measure and record vertical movement at each equipment anchor during loosening and retightening. Measure vertical movement using a magnetic-based dial indicator on the baseplate, soleplate, or fabricated steel frame referenced to the epoxy grout surface of the equipment pad, or other approved method. Vertical movement exceeding 25 micrometers (0.001 inch) indicates a soft foot condition. Soft foot conditions are sufficient cause for removal and reinstallation of grout and baseplates, soleplates, or fabricated steel frames.
   6. Check for grout voids by tapping along the upper surfaces of the baseplate, soleplate, or mounting block. Mark grout voids. A grout void is sufficient cause for removal and reinstallation of grout and baseplate, soleplate, or fabricated steel frame. At the discretion of the Construction Manager, grout voids may be repaired as specified in Chapter 5, Section 3.16 of API RP 686.

D. Piping Connections:
   1. Anchor piping connecting to flexible connections and/or expansion joints such that the intended function of these connections/joints is maintained in the piping system without imposing strain on the equipment connections.
   2. Where an equipment manufacturer's installation requirements include a rigid connection between the machine and connecting piping systems, delete any flexible coupling (including equipment connection fittings) shown on the drawings and install the equipment in the following manner, in lieu of installing the flexible coupling:
      a. Install equipment pad as shown in the detail specified in the Equipment Mounting Schedule or in the individual equipment specification.
      b. Install the baseplate, soleplate, or fabricated steel frame supporting the equipment and grouted in place as specified in this Section.
      c. Install and align the equipment in place as specified in Section 43 05 14.

d. Install and align piping between equipment connections and field piping without welding one of the joints for one section of pipe between the equipment connection and the field piping and all valving. All flanged joints bolted up and pressure-tested.

e. All piping must be fully supported by supports designed to accept their full weight and thrust forces.

f. Install the final section of piping. Align the final section of pipe with the equipment and field connections without the use of jacks, chain falls, or other devices to force it into alignment.

g. Do not weld the final piping joints until after the previous steps have been completed and accepted by the Construction Manager.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Services

1. Epoxy Grout Training: Prior to commencing rigid equipment mount installation work on equipment pads, furnish the services of a grout manufacturer's technical representative to conduct a training school for the workers who will be using epoxy grout for rigid equipment mount installations. Epoxy grout training school duration to be not less than 4 hours duration and covers all aspects of using the products, including form construction for each equipment installation, surface preparation, mixing, application, void prevention/elimination, and clean up. This requirement does not relieve the Contractor of overall responsibility for this portion of the work. Epoxy grout manufacturer to furnish a list of school attendees who have been satisfactorily trained to perform epoxy grout installation for equipment mounting.
2. Epoxy Grout Quality Control: The epoxy grout manufacturer's technical representative provides quality control services for equipment mounted with epoxy grout. The epoxy grout manufacturer's technical representative must be present (on site) to inspect and verify that the installation personnel have successfully performed surface preparation, epoxy grout application, and Quality Control Inspection in accordance with these specifications for a representative portion of the epoxy grout installation work.
3. Epoxy grout manufacturer's technical representative performs the following services for at least one rigid equipment mount installation for each equipment type and size installed with epoxy grout:
    a. Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer's requirements.
    b. Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied. Inspect surface for conformance to the specified application criteria, including but not limited to substrate profile, degree of cleanliness, and moisture.
    c. Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.
    d. Inspect the epoxy-primed metallic substrate for coverage and adhesion.
    e. Inspect preparation and application of epoxy grout form work for conformance to the specifications and manufacturer's recommendations for form edge clearance.
    f. Inspect and record that the "pot life" of epoxy grout materials is not exceeded during installation.
    g. Inspect epoxy grout for cure.

h. Inspect and record that localized repairs made to grout voids conform to the specification requirements.

i. Conduct a final review of completed epoxy grout installation for conformance to these specifications.

j. Attest to conformance of the Contractor's work by signing appropriate entries in the "Rigid Equipment Mount Inspection Checklist," Form 43 05 13-A in Section 01 99 90.

B. Training and quality control by the grout manufacturer's technical representative is not required for rigid equipment mounts installed with cementitious non-shrink grout.

3.04 FINAL INSPECTION

A. The Construction Manager will conduct a final inspection with the Contractor for conformance to requirements of this Section.

PART 4 EQUIPMENT MOUNTING SCHEDULE

Equipment Mounting Schedule

Equipment Number	Specification Section	Specification Title	Equipment Pad Detail	Mounting Plate Leveling Tolerance (inch/foot)	Equipment Anchor Type	Equipment Anchor Sleeve Length	Grout Type	Application Notes
Default Config.	*Various*	*Various*	*D01007*	*0.005*	*D01002*	*10D*	*Non-shrink*	*Default equipment mounting configuration for all equipment not otherwise specified in this schedule*
Freestanding floor-mounted electrical panels and equipment	*Various*	*Various*	*D01006*	*Not applicable*	*D01004*	*Not required*	*Not required*	
TBD	*TBD*	*Vertical Turbine Pumps*	*D01007*	*0.0005*	*D01003*	*15D*	*Epoxy*	
TBD	*11325*	*Multistage Vertical Centrifugal Pumps*	*D01007*	*0.002*	*D01002*	*15D*	*Non-shrink*	
TBD	*13216*	*Cross-Linked Polyethylene Tanks*	*Existing*	*No mounting plate*	*D01003*	*Not required*	*None*	

END OF SECTION

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SECTION 43 05 14

MACHINE ALIGNMENT

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies requirements for alignment of directly coupled mechanical equipment weighing 1000 pounds or more and/or greater than 5 horsepower furnished or modified under this contract.

B. Equipment direct coupled to the motor with drivers 5 horsepower and less and belt or chain driven machinery are specifically exempted from the requirements of this section.

C. Separately mounted equipment connected by offset universal joints are exempted from the offset and angularity requirements, but all units must be installed and leveled as specified in this section and referenced sections.

1.02 RELATED SECTIONS

A. Section 43 05 11 – General Requirements for Equpment

B. Section 43 05 13 – Rigid Equpment Mounts

C. Section 43 05 17 – Vibration and Critical Speed Limitations

D. Section 43 23 03 – General Requirements for Centrifugal and Axial Flow Pumps

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASA S2.75 Part 1	Shaft Alignment Methodology, Part 1: General Principals, Methods, Practices, and Tolerances
ANSI/ASA S2.75 Part 2	Shaft Alignment Methodology, Part 2: Vocabulary

Reference	Title
ANSI/ASA S2.75 Part 3	Shaft Alignment Methodology, Part 3: Alignment of Vertically Oriented Rotating Machinery
Shaft Alignment Handbook	Shaft Alignment Handbook, Third edition, John Piotrowski, Marcel Dekker Inc.

1.04 DEFINITIONS

A. Follow definitions as defined in ANSI/ASA S2.75, Parts 1, 2, and 3.

1.05 QUALITY ASSURANCE

A. General:
   1. All equipment shall be aligned using laser alignment equipment to the tolerances specified by the subject equipment manufacturer or the criteria specified in this section, whichever is more stringent.

B. Alignment Criteria:
   1. Unless otherwise specified by more stringent manufacturer's requirements or the the detailed equipment specification:
      a. Meet the level, flatness, and coplanarity limits in ANSI/HI S2.75, Part 1, Table 1, for equipment bases and sole plates..
      b. Comply with shaft runout tolerances in ANSI/HI S2.75, Part 1, Table 2,
      c. Conduct a test for soft foot prior to aligning machines.
         1) Soft foot (machine frame distortion) shall be not more than 2.0 mils for any speed.
      d. Align all process equipment, including pumps, blowers, turbines, and similar machines to meet the Precision Tolerance Range in Tables 3 and 4 of ANSI/ASA S2.75, Part 1.

C. Qualifications:
   1. All alignment work shall be performed by millwrights trained in the use of the laser alignment equipment by the manufacturer.

1.06 SUBMITTALS

A. Provide in accordance with Section 01 33 00:
   1. Action Submittals:
      a. Prior to testing, provide a Testing Plan Report identifying, for each piece of equipment, testing location and passing measurement values for each location and test type.
      b. Summary report verifying compliance with the alignment criteria as set forth in paragraph 1.06.B. Include hard copy of all alignment records, signed and dated by the technician performing the work.
      c. Electronic files, including both a summary (pdf) file and files native to the alignment software used for completing the work specified in this section.
      d. Qualifications of the alignment technician.
         1) Millright training
         2) Training certification from the laser alignment equipment manufacturer

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Laser alignment equipment shall be:
   1. Easy-Laser®
   2. PrufTechnik
   3. ACOEM,
   4. or approved equal.

B. Alignment equipment used to perform the work required under this section shall employ laser alignment techniques to achieve the required tolerances. The equipment shall be computer based and its software shall be compatible with current Windows® based spreadsheets and databases. The equipment shall employ a hand-held field computer using a graphic interface to determine actual alignment and necessary corrective action to bring equipment into required tolerance. The link between field measurement components and the computer shall be through cable, infrared, or wireless transmission.

PART 3 EXECUTION

3.01 GENERAL

A. After machine base grouting as specified in Section 43 05 13, align all machines mounted on baseplates or soleplates as specified in this section.

B. Alignment work shall be performed by journeyman millwrights skilled in this type of work under the supervision of a technician trained in the use of the laser alignment by the manufacturer or vendor of the alignment equipment. The use of untrained laborers, carpenters or apprentices for this work will not be acceptable.

C. Submit alignment report for each machine within 2-weeks of completing the alignment.

3.02 PROCEDURE

A. Sequence:
   1. Machines supported on integral feet or support pads shall be leveled, grouted and aligned in the following order: driven machine; intermediate bearings or machines; and driver. Under certain circumstances, such as a diesel engine driving a generator, it may be preferable to reverse this order and set the driver first. The Contractor shall submit a written request for a reversal of the alignment order to the Construction Manager and the Construction Manager must approve any change in alignment order in writing before it will be allowed.

B. Alignment:
   1. All machines shall be rough aligned without any connections to piping, electrical and instrumentation systems. Upon completion of all field connections, alignment shall be rechecked to demonstrate no change. If change has occurred, the Contractor shall eliminate any external forces affecting machine alignment.

2. Next, soft foot (machine frame distortion) shall be measured and brought to within the permissible tolerances. Thereafter, the alignment shall be rechecked and the alignment process repeated if necessary to bring all machinery to final alignment tolerances.

3.03 VERIFICATION

A. Factory Personnel:

1. Where required by other sections in this project manual, factory authorized installation technicians representing the equipment manufacturer shall witness final alignment work. After completion of all alignment work, acceptance of the work shall be documented in writing by factory authorized installation technicians.

END OF SECTION

SECTION 43 05 17

VIBRATION AND CRITICAL SPEED LIMITATIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies vibration and critical speed limitations for rotating mechanical equipment. Factory and/or field testing and vibration measurements shall be taken when specified in the individual equipment specification sections.

1.02 VIBRATION LIMITATIONS

A. General:
   1. Vibration frequencies shall span the range from 5.0 to 5000 Hz. Where specified, measurements shall be obtained while the installed equipment is operating within the specified speed range.

B. Centrifugal:
   1. Machines With Sleeve Bearings:
      a. Unless otherwise specified, centrifugal machines with sleeve bearing shafts shall not exhibit unfiltered RMS readings for vibration displacement in excess of the following:

Shaft speed range, rpm	Displacement, peak to peak, mils
Up to 900	3.5
901-1800	3.0
1801-3000	2.5
3001-4500	2.0
Above 4500	1.6

      b. Displacement measurements shall be taken radially on the shaft at two points at each bearing, except for well pumps which shall be measured at top of motor. Measuring points shall be 90 degrees apart.
   2. Machines with Antifriction Bearings:
      a. Unless otherwise specified, centrifugal machines with antifriction bearing shafts shall not exhibit unfiltered RMS readings for vibration velocity in excess of 0.12 inch per second. Velocity measurements shall be taken on one point of each bearing housing.

C. Positive Displacement Machines:
   1. Unless otherwise specified, positive displacement machines of the rotary, reciprocating and controlled volume types shall operate without any lateral or torsional vibration characteristics that may accelerate wear of the equipment. The Contractor shall provide manufacturer's certification that the manufacturer has inspected the machine under operating conditions and found it to comply with the requirements of this paragraph.

1.03 CRITICAL SPEED REQUIREMENTS

A. Unless otherwise specified, rotating mechanical equipment shall not exhibit critical speeds within the specified range of operating speeds. Critical speeds for equipment with rigid rotor systems shall be at least 20 percent greater than maximum operating speed. Critical speeds for equipment with flexible shaft-rotor systems shall be at least 15 percent below minimum operating speed and 20 percent above maximum operating speed.

PART 2 PRODUCTS

2.01 PRODUCT DATA

A. Manufacturer's certified data showing location of critical speeds in relation to operating speeds shall be provided as product data in accordance with Section 01 33 00.

PART 3 NOT USED

END OF SECTION

SECTION 43 05 18

VIBRATION ISOLATION SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies vibration isolation system requirements for mechanical equipment. Additional vibration isolation system requirements are provided in individual mechanical equipment specification sections. Mountings which are rigidly anchored to the supporting floor system are specified in Section 43 05 13.

B. Mounting Requirements:

1. Unless the equipment incorporates unit construction using an integral rigid frame or is specified otherwise, each item of mechanical equipment, along with its drive unit, shall be mounted on a rigid steel or steel and concrete base. Cast iron bases are not permitted when equipment is furnished with a vibration isolation system. Where specified, the equipment, including the base, shall be mounted on or suspended from vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the supporting structure. Vibration isolation available internally in the equipment will not be considered equivalent and shall not be provided when vibration isolation as specified herein is required. Normally provided internal vibration isolators shall be replaced with rigid supports in such cases. Vibration isolators shall be selected in accordance with unit weight distribution to produce reasonably uniform deflections at each support. Unless otherwise specified, bases, isolators, and deflections shall be as specified in the 2019 ASHRAE Handbook for HVAC Applications, Chapter 49, Noise and Vibration Control, Table 47.

C. Design Requirements:

1. The Contractor shall cause all vibration isolation systems, including the isolators, seismic restraints and flexible connectors between the isolated equipment and associated piping, ducting and/or electrical work, to be designed by a professional engineer qualified in this type of work. This provision, however, shall not be construed as relieving the Contractor of his overall responsibility for the work. The Contractor shall submit a copy of the engineer's calculations for design of the vibration isolation systems, stamped with the engineer's seal. Flexible connectors shall be provided by the manufacturer of the mechanical equipment item in accordance with the recommendations of the vibration isolation system engineer.

D. Seismic Restraints:

1. General:

a. Restraint devices shall be designed to resist seismic forces for the project location in accordance with the requirements of the IBC and ASCE-7. Design lateral forces shall be distributed in proportion to the mass distribution of the equipment.

2. Floor Mounted Equipment:
    a. Equipment and appurtenances resiliently floor mounted on spring or pad type vibration isolators, except for curb mounted equipment, shall be provided with seismic snubbers. Equipment shall receive four all-directional restraint/snubbers. The capacity of snubbers, at 3/8-inch deflection, shall be 3 to 4 times the load at the adjacent equipment mount.
        1) Restraint assembly for floor mounted equipment shall consist of welded steel interlocking assemblies welded or bolted securely to the equipment or the equipment bases and the supporting structure. Restraint assembly surfaces which engage under seismic motion shall be lined with a resilient elastomer, 3/4 inches thick. Restraints shall be field adjustable and be positioned for 1/4-inch clearance both vertically and horizontally or clearance as required to prevent interference during normal operation, stopping, or starting. Restraint assembly shall be designed in accordance with the requirements of the IBC and ASCE-7 for the project location.
3. Curb Mounted Equipment:
    a. Seismic restraints for equipment mounted on vibration isolation curbs shall consist of slack stainless steel cables designed to provide restraint in the four primary horizontal directions based on the requirements in the IBC and ASCE-7 for the project location.
4. Suspended Equipment:
    a. Restraint assembly for suspended equipment, piping, or ductwork shall consist of plow steel cable attached to steel thimbles with neoprene sleeve all specifically designed for cable service and securely fastened to the equipment, or the equipment base and the building structure. Cables shall be sized in accordance with the requirements of the IBC and ASCE-7 for the project location. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation, starting, or stopping.
5. Testing:
    a. Seismic restraint tests shall be conducted in an independent laboratory or under the supervision of an independent registered engineer. The snubber assemblies shall be bolted to the test machine as the snubber is normally installed. Test reports shall certify that neither the elastomeric nor the snubber body sustained any obvious deformation after release of load.

1.02 REFERENCES:

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ASHRAE CH 49	Handbook, HVAC Applications, Noise and Vibration Control
IBC	International Building Code with local amendments
SMACNA	Seismic Restraint Manual Guidelines for Mechanical Systems

1.03 SUBMITTALS

A. Provide in accordance with Section 01 33 00:

B. Action Submittals:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Scale drawing of Type D mounting hanger showing the 30-degree arc capability.
3. Manufacturer and manufacturer's type designation.
4. Manufacturer's catalog data.

C. Informational Submittals:

1. Seismic system design calculations as specified in paragraph 1.01 Design Requirements.
2. Seismic restraint test reports specified in paragraph 1.01 Seismic Restraint, Testing.
3. Installation report specified in paragraph 3.02.
4. Static and dynamic deflections, weights, isolator locations, and flexible connector designs.

5. Spring deflections and diameters, compressed spring heights and solid spring heights.
6. Curb mounted base seal and wind resistance details.
7. Seismic restraint load deflection curves up to 1/2-inch deflection along the three principal orthogonal axes.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Vibration isolation mountings and seismic restraints shall be as manufactured by Mason Industries, Inc., Korfund Dynamics, Kinetics Noise Control, or equal. Flexible connectors shall be provided by the manufacturer of the mechanical equipment item in accordance with the recommendations of the vibration isolation system engineer.

2.02 BASES

A. Curb Mounted Bases:
   1. Curb mounted equipment where vibration isolation is required, principally roof top heating, ventilating and air conditioning equipment, shall be mounted on vibration isolation bases that fit over the curb and under the isolated equipment. The extruded aluminum top and bottom members shall contain cadmium-plated springs having a 1-inch minimum deflection with 50 percent additional travel to solid. Spring diameters shall be no less than 0.8 times the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4 inch so as not to interfere with spring action except in high winds. The weather seal shall consist of continuous closed cell sponge materials both above and below the base and a waterproof flexible neoprene connection duct joining the outside perimeter of the aluminum members. Foam or other contact seals are unacceptable at the spring cavity closure. Caulking shall be kept to a minimum.

B. Type I Bases:
   1. Type I bases shall be structural steel bases. The bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases, which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10 of the longest dimension of the base. Beam depth need not exceed 14 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1-inch.

C. Type II Bases:
   1. Type II bases shall be steel members used to cradle machines having legs or bases that do not require a complete supplementary base. All members shall be sufficiently rigid to prevent strains in the equipment. Height saving brackets shall be employed in all mounting locations to provide a clearance of 1-inch below the base.

D. Type III Bases:

1. Type III bases shall be rectangular foundations consisting of concrete filled structural steel beam or channel forms. Bases for split case pumps shall be of sufficient size to provide support for suction and discharge base ells. The base depth need not exceed 12 inches unless specifically recommended by the base manufacturer or required for mass or rigidity. In general, base depth shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 inches. Forms shall include, as a minimum, concrete reinforcement consisting of 1/2-inch bars or angles welded in place on 6-inch centers each way in a layer 1 1/2 inches above the bottom or additional steel as required by structural conditions. Forms shall be provided with drilled steel members with sleeves welded below the holes to receive equipment anchor bolts where the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1-inch clearance below the base.

E. Type IV Bases:

1. Type IV bases are cast iron bases as specified in Section 43 05 13 and are not permitted when equipment is furnished with vibration isolators.

2.03 VIBRATION ISOLATION MOUNTINGS

A. Type A Mountings:

1. Type A mountings shall be double deflection neoprene mountings having a minimum static deflection of 0.35 inches. All metal surfaces shall be neoprene covered to avoid corrosion and shall have friction pads both top and bottom so that they need not be bolted to the floor. Bolt holes and anchor bolts shall be provided where required to resist lateral migration. Resilient washers and bushings shall be provided to prevent contact between the bolts and the equipment support bases. On equipment such as small vent sets, steel rails shall be used above the mountings to compensate for the overhang.

B. Type B Mountings:

1. Type B mountings shall be free-standing spring type isolators laterally stable without any housing and complete with 1/4-inch neoprene acoustical friction pads between the base and the support. Mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 times the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall be hot-dip galvanized steel.

C. Type C Mountings:
   1. Type C mountings shall be Type B mountings with a housing having vertical limit stops to prevent spring extension when weight is removed. Type C mountings shall be provided for equipment with operating weight different from the installed weight, such as chillers, boilers, etc., and equipment exposed to the wind, such as cooling towers. The housing shall serve as blocking during erection and shall be located between the supporting steel and roof or the grillage and dunnage as shown on the drawings. The installed and operating heights shall be the same. a minimum clearance of 1/2 inch shall be maintained around restraining bolts and between the housing and the spring to prevent interference with the spring action. Limit stops shall be out of contact during normal operations. Mountings shall be hot-dip galvanized steel.

D. Type D Mountings:
   1. Type D mountings shall be steel hangers which contain a steel spring and a 0.3-inch deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing which passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be of sufficient size to permit the hanger rod to swing through a 30-degree arc before contacting the hole. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection.

E. Type E Mountings:
   1. Type E mountings shall be double deflection, cork and rubber sandwich pads consisting of a high-density cork layer permanently bonded to top and bottom layers of corrugated oil-resistant synthetic rubber. The corrugated design shall allow deflection to increase with load and shall form a nonskid surface to resist lateral migration of the equipment. Bolt holes and anchor bolts shall be provided where required to resist migration. Resilient washers and bushings shall be provided to prevent contact between the bolts and the equipment support bases.

PART 3 EXECUTION

3.01 GENERAL

A. Seismic restraints shall be securely anchored or fastened to the equipment and supporting structure in accordance with approved submittal data. Operating clearances shall be adjusted so that restraints do not interfere during normal operation of the equipment.

3.02 FIELD INSPECTION

A. The vibration isolation manufacturer, or his qualified representative, shall provide such supervision as is necessary to assure correct installation and adjustment of the isolators and seismic restraints. Upon completion of the installation and after the system is put into operation, the manufacturer, or his representative, shall make a final inspection and submit his report in writing certifying the correctness of installation and compliance with approved submittal data.

END OF SECTION

SECTION 43 05 21

COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Squirrel cage type, AC induction motors, up to 500 HP, for up to 4 poles (3600 or 1800 rpm nominal), or up to 250 HP for over 6 poles (1200 rpm or slower) shall be per NEMA MG1, Small or Medium.
   2. Special purpose motors with features or ratings which are not specified herein, are specified in the particular equipment specifications.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 26 29 23 Variable Frequency Motor Controllers

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry- Premium-Efficiency, Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators
Department of Energy	Energy Policy and Conservation Act, Final Rules EERE-2010-BT-STD-0027-0117
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 1004	Electric Motors

1.04 DEFINITIONS

A. Terminology used in this Section conforms with NEMA MG-1. Motors covered in this specification are those defined in NEMA MG1 as Small (Fractional) and Medium (Integral) AC induction motors.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility: Where Unit Responsibility is specified in the driven equipment sections of these specifications, the motor supplier shall coordinate with the provider of the driven equipment to verify that the motor provided under this section is fully compatible with and meets the specified performance requirements for that equipment.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
      a. Copy of this Section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      b. Check-marks (✓) to denote full compliance with a paragraph as a whole. Underline deviations and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance. Include a detailed, written justification for each deviation.
      c. Failure to include a copy of the marked-up specification sections with justification(s) for any requested deviation will cause rejection of the entire submittal with no further consideration.
   2. Motor Data Sheets specified in this Section and Division 01.
      a. Motors in conformance with IEEE 841: Manufacturers to complete IEEE Standard 841 Data Sheet for AC Induction Motors.
      b. Motors not in conformance with IEEE 841: Motor supplier to complete Form 43 05 21-A in Section 01 99 90 with required factory data.
      c. Motor Speed-Torque curve, where specified.
   3. Routine Factory test data for polyphase motors.
      a. High-potential test.
   4. Factory test data, from required dynamometer tests, where specified.
   5. Vibration level when measured in accordance with NEMA MG 1, for all IEEE 841 motors, and where elsewhere specified.
   6. Motor heating curve, where specified,
   7. Motor mounting, outline, dimensions, and weight.
   8. Motor bearing and winding RTDs (resistance temperature detector), where specified.
   9. Motor winding thermostat or thermistor, where specified.
   10. Motor winding space heaters, where specified.
   11. Motor nameplate data.

B. Informational Submittals:
   1. Procedures: Section 01 33 00 and 01 78 23.
   2. Submittal requirements for operation and maintenance manuals as per requirements of Section 01 78 23.

1.07 QUALITY ASSURANCE

A. Factory Testing:
   1. All polyphase motors shall be factory tested in conformance with routine tests per NEMA MG1 and IEEE 112. Provide the following tests:
      a. Measurement of winding resistance.
      b. No-load readings of current and speed at normal voltage and frequency.
      c. Current input at rated frequency with rotor at standstill.
      d. High potential test.

B. Where specified for use in corrosive or hazardous locations, motor testing shall additionally be per IEEE 841. Test report shall be certified by the motor manufacturer's test personnel and submitted to the Engineer.
   1. For motors larger than 100 horsepower, test and submit results for the following:
      a. Routine tests per NEMA MG1 and IEEE 112. Provide tests as noted in paragraph 1.07 Factory Testing. Test report shall be certified by the motor manufacturer's test personnel and submitted to the Engineer.
      b. For motors larger than 200 horsepower, efficiency and power factor by Test Method B, IEEE 112. Submit Form B and B-2.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures shall be in accordance with Section 01 66 00.

1.09 SPECIAL WARRANTY

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

B. Submit warranties in writing to include 100 percent full payment coverage for parts and labor for repair or replacement of the motor (s) during the warranty period.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Baldor
   2. General Electric
   3. Siemens
   4. US Motors
   5. WEG
   6. Approved Equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:
   1. Temperature: -25-degree C to +40 degree C.
   2. Altitude: 0 to 3300 feet above sea level minimum.
   3. Derate motors for higher ambient temperature and for higher altitude with motor size based on brake-horsepower.

B. Design Requirements:
   1. Operation: Continuous.
   2. Compliance: Energy Policy Act of 1992 (EPAct), Final Rule 2014.
   3. Tolerance: +/- 10-percent of rated voltage at rated frequency; +/- 5-percent of rated frequency at rated voltage.
   4. Standard design: NEMA Design B.

C. Service Factor (percent of additional horsepower):
   1. 1.15 for Sine-wave motors.
   2. Dual rating: 1.15 Sine-wave and 1.0 Inverter Duty for Inverter Duty motors.

D. Motor Efficiency:
   1. NEMA Premium™ efficiency electric motor, single-speed, polyphase, 1-500 horsepower, 3600-rpm 2-pole, 1800-rpm 4-pole, and 1200-rpm 6-pole (1-250 HP), squirrel cage induction motors, NEMA Design B, continuous rated. NEMA Standards Publication MG 1 2011, in Table 12-12.

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Open Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84	81.5	86.5	84.0	86.5	84.0	77.0	74.0
2	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
3	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
5	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
10	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
15	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
20	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
25	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5
30	91.7	90.2	94.1	93.0	93.6	92.4	91.7	90.2
40	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	91.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	93.0	91.7

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Open Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
75	93.6	92.4	95.0	94.1	94.5	93.6	94.1	93.0
100	93.6	92.4	95.4	94.5	95.0	94.1	94.1	93.0
125	94.1	93.0	95.4	94.5	95.0	94.1	94.1	93.0
150	94.1	93.0	95.8	95.0	95.4	94.5	94.1	93.0
200	95.0	94.1	95.8	95.0	95.4	94.5	94.1	93.0
250	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
300	95.4	94.5	95.8	95.0				
350	95.4	94.5	95.8	95.0				
400	95.8	95.0	95.8	95.0				
450	96.2	95.4	96.2	95.4				
500	96.2	95.4	96.2	95.4				

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Enclosed Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
2	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
3	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
5	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
7.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
10	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
15	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
20	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
25	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5
30	91.7	90.2	93.6	92.4	93.0	91.7	91.7	90.2
40	92.5	91.0	94.2	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	92.4	91.0
75	93.6	92.4	95.4	94.5	94.5	93.6	93.6	92.4
100	94.1	93.0	95.4	94.5	95.0	94.1	93.6	92.4
125	95.0	94.1	95.4	94.5	95.0	94.1	94.1	93.0
150	95.0	94.1	95.8	95.0	95.8	95.0	94.1	93.0
200	95.4	94.5	96.2	95.4	95.8	95.0	94.5	93.6
250	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
300	95.8	95.0	96.2	95.4				
350	95.8	95.0	96.2	95.4				
400	95.8	95.0	96.2	95.4				
450	95.8	95.0	96.2	95.4				
500	95.8	95.0	96.2	95.4				

2.03 MATERIALS

A. Motor frames:
   1. TEFC motors shall be cast iron.
   2. Aluminum frame motors are not permitted.

B. Stator windings:
   1. Shall be copper with Class F minimum insulation not to exceed Class B temperature rise of 80-degree C at rated load and with Design B torque /current characteristics for all Medium (Integral) motors.
   2. Small (fractional) motors shall be supplied with Class F insulation where available.

C. Rotor material shall be aluminum or copper.

D. Fans shall be non-sparking fan blades.

E. Motor leads shall be non-hygroscopic.

2.04 MOTOR TYPES

A. General Requirements for motors 1/2 horsepower through 500 horsepower:
   1. Three phase, squirrel cage, with copper windings.
   2. Rated for full voltage starting and continuous duty.
   3. Rating shall be:
      a. 460/ 230 volts, three-phase, 60-Hertz, as shown on the contract drawings.
   4. General Purpose Type motors, which may also be called Type 1 per the project equipment specifications shall be:
      a. Open Drip Proof Motors, shall be as defined per NEMA MG1, self-cooled by convection air.
      b. Weather-Protected Type I Motors (WP-I), shall be as defined per NEMA MG1, similar to ODP construction with addition of screens to prevent entry of rain, snow, and particles, or objects into the motor. Suitable for clean indoor and protected outdoor installations.
      c. Weather Protected Type II Motors (WP-II) shall be as defined per NEMA MG1, with maximum protection from entry of airborne particles, moisture and high velocity air. Suitable for unprotected outdoor installations.
   5. Severe Duty Type Motors, which may also be called Type 2 per the project equipment specifications, shall be in accordance with IEEE 841.
      a. Totally Enclosed Fan-Cooled Motors (TEFC) shall be defined per NEMA MG1.
      b. Enclosure: totally enclosed, fan cooled, with external fan blowing air to the motor frame cooling fins for cooling.
      c. Applications: severe duty and most outdoor installations.
   6. Explosion Proof Type Motors, which may also be called Type 3 per the project equipment specifications.
      a. Enclosures: UL listed explosion proof
      b. Applications: hazardous locations including Class I and Class II (Division 1 and 2), and Class III classified areas.

B. Motors Less Than 1/2 Horsepower:
   1. Type shall be:
      a. Squirrel cage, capacitor start with Class F insulation and copper windings.
      b. Fan motors rated 1/8 horsepower or less: split-phase or shaded-pole type.
   2. Rating shall be:
      a. 115Volts, single phase, 60 Hz.
      b. 208 Volts, single phase, 60 Hz.
      c. 230 Volts, single phase, 60 Hz..

2.05 COMPONENTS

A. Inverter-Fed Polyphase Motors per NEMA MG1 Part 31:
   1. Applications: variable torque or constant torque loads, for vertical or horizontal motors with variable frequency drive controllers (VFD).
   2. Features shall include:
      a. Insulation design to meet 2000-Volt peak at a minimum of 0.1 micro-second rise time.
      b. Built-in motor winding protection as specified.
      c. Electrically insulated bearings or,
      d. Provide Electro Static Technology's AEGIS Shaft Grounding Ring for Bearing Protection or equal. The shaft grounding ring shall be solidly bonded per manufacturer's recommendations.

B. Vertical Motors:
   1. Features: Inverter duty or non-inverter duty with solid shaft P-base and high thrust bearing compatible with loads imposed by the driven equipment.

C. Thermal Protection:
   1. Unless specified otherwise in the driven equipment specification, provide the following:
      a. Motors up to 200 horsepower:
         1) Thermal switches (thermostats), one per winding, encapsulated, normally closed and wired in series out to a terminal box).
         2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.
   2. Motors larger than 250 horsepower:
      a. 100 ohm platinum RTDs, two per phase embedded in each winding phase and one for each motor bearing.
      b. RTDs shall be brought out to a separate control terminal box mounted on the motor.
      c. Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.

D. Motor Nameplates:
   1. Materials: Engraved or stamped stainless steel.
   2. Features shall be as follows:
      a. NEMA Standard MG 1 motor data.
      b. Permanently fastened to the motor frame.
      c. ABMA bearing identification number for motors meeting IEEE 841.
      d. NEMA nominal efficiency for all motors.
      e. NEMA nominal and minimum efficiency for motors meeting IEEE 841.
      f. UL frame temperature limit code for explosion proof motors.
      g. Space heater data.
      h. Over Temperature Protection Type Number.

i. Temperature device rating and alarm and shutdown setpoint.

j. Provide motor nameplates for motors with space heaters located in Class I, Division 2, Groups C, and D areas in accordance with NEC 501.125(B).

E. Conduit Boxes:

1. Provide oversized boxes, with split construction with threaded hubs and petroleum-resistant gaskets.
2. Conduit boxes can be rotated in order to permit installation in any of four positions 90 degrees apart.
3. Provide grounding lug located within the conduit box for ground connection.
4. Provide separate conduit boxes for temperature devices and space heaters.
5. Separate terminal box for any signal leads (RTD, thermistor, vibration transmitter, etc.).

F. Bearings:

1. Provide oil or grease lubricated ball bearings, angle contact roller bearings for axial thrust loads, and cylindrical bearings for radial-only loads.
2. Rated for a minimum L-10 life of 50,000 hours for direct-connected loads.
3. Cartridge type bearings will not be accepted.
4. Fitted with lubricant fill and drain or relief fittings.
5. Belt loads not to exceed forces calculated from NEMA MG 1 Table 14-1 and 14-1A.

G. Bearing lubrication shall be either grease or oil as per the requirements in either 1 or 2:

1. Grease lubricated bearings:
   a. Shall be for electric motor use only.
   b. Grease shall be capable of higher temperatures associated with electric motors and shall be compatible with Polyurea-based greases.
   c. Provide grease fittings, similar to Alemite™ type (or equivalent).
   d. Shielded bearings with regreasable provisions are permissible.
2. Provide oil lubricated bearings with externally visible sight glass to view oil level.

H. Lifting Eyes:

1. Provide lifting eyes with a safety factor of 5.
2. Provide one lifting eye for motors more than 50 pounds.
3. Provide two lifting eyes for motors over 150 pounds.

I. Winding Space Heaters when specified or shown:

1. Provide winding space heaters to prevent condensation.
2. Rating: 120 volts, single phase, 60 Hertz.
3. Motor nameplate to show space heater rating in watts and volts.
4. Provide terminal block in motor conduit box for heater leads termination.

2.06 FINISHES

A. Paint Finish:

1. Provide standard manufacturer paint finish.

2. Provide motors with semi-gloss finish, scratch and heat resistance electric motor paint.

PART 3 EXECUTION

3.01 EXAMINATION

A. Delivery Inspection:
   1. Inspect driven equipment-motor assembly and components immediately upon delivery and unloading at the job site for damages.
   2. Take photos of damage(s) if any, to substantiate the delivery inspection report.

3.02 INSTALLATION

A. Grounding of Motors:
   1. Connect the motor feeder ground cable (green) to the grounding lug terminal in the conduit terminal box.

B. Supplemental Grounding of Motors: Provide for motors fed from VFDs, all motors above 100 horsepower, and all motors in classified areas, where feasible.
   1. Bond the motor frame to the grounding grid/electrode system to provide supplemental grounding.

C. Field Coating of Motors:
   1. Refer to the driven equipment specification section and Section 09 90 00 for coating requirements.

3.03 FIELD QUALITY CONTROL

A. Field Testing:
   1. Measure winding insulation resistance of motors to no less than 10-megohm with a 1000-Vac megohmmeter.
   2. Perform motor phases current imbalance testing for motors 20 horsepower and larger.
   3. Test motors for proper rotation prior to connection to the driven equipment.
   4. Perform thermographic survey per NETA ATS, for motors over 100 horsepower.

B. Field Inspection:
   1. Compare equipment nameplate data with drawings and specifications.
   2. Inspect physical and mechanical condition.
   3. Inspect anchorage, alignment, and grounding.
   4. Verify the installation of breather/drain fittings as specified herein.
   5. Check for proper connections of space heaters, winding and RTDs and or thermostats.
   6. Visually check for correct phase and ground connections:

C. Manufacturer Services: Provide where specified or shown on the drawings.
   1. Provide services to the driven equipment manufacturer for the inspection and certification of the installation of the motor driven equipment.
   2. Provide assistance in the start up and operational testing of the motor driven equipment.

3.04 SYSTEM START UP

A. Commissioning Test: Provide where specified or shown on the drawings.
   1. Provide assistance during the commissioning test of the motor driven equipment.

3.05 CLOSEOUT ACTIVITIES

A. Operation and Maintenance:
   1. Provide the operation and maintenance manual of the motor(s). Include testing result information in the O&M manual.

END OF SECTION

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SECTION 43 11 17.16

HORIZONTALLY SPLIT MULTISTAGE CENTRIFUGAL BLOWERS, CONSTANT VOLUME

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies electric motor driven multistage centrifugal blowers with appurtenances for use in constant volume applications.

B. Type:
   1. Motor driven blowers provided under this section shall be of the multistage centrifugal type with outboard shaft bearings. The blower shall be direct connected to an electric motor driver through a flexible coupling. Included with the blower shall be the drive motor, blower controls, base, vibration detection system, intake and discharge flexible couplings, valves, and other items as specified.

C. Definitions:
   1. Standard Cubic Feet Per Minute (SCFM):
      a. The volumetric flow rate in cubic feet per minute at 68 degrees F, 14.70 pounds per square inch absolute pressure and 36-percent relative humidity.
   2. Actual Cubic Feet Per Minute (ACFM):
      a. The volumetric flow rate in cubic feet per minute actually entering the blower at the site temperature, pressure, and relative humidity.
   3. Absolute Pressure (PSIA):
      a. The total pressure measured from an absolute vacuum is the absolute pressure. Units are pounds per square inch absolute (psia).
   4. Discharge Pressure (PSIG):
      a. The pressure at the compressor discharge at site conditions. Units are pounds per square inch gauge (psig).
   5. Inlet Cubic Feet Per Minute (ICFM):
      a. Same as actual cubic feet per minute.

D. Equipment List:

Item	Equipment Number
Blower 1	70-B-00010
Blower 1 Check Valve	00014
Blower 1 Control Valve	CV-00013
Blower 1 Silencer	70-SLR-00030
Blower 2	70-B-00020
Blower 2 Check Valve	00024
Blower 2 Control Valve	CV-00023

E. Performance and Design Requirements:

1. General: The multistage centrifugal blower provided under this section will be operated as a duty/standby system with similar equipment to produce scour air for filter backwashes. The blower will be operated at constant volume.
2. Operating Conditions: The blowers will be installed in reinforced concrete building which will be ventilated with filtered, tempered air. Ambient temperatures within the room are expected to range between 60 and 85 degrees F. The plant site is located at approximately 5320 feet above sea level. Blower supply air will be taken from medium efficiency viscous panel filters located on independent blower air intake ducts.
3. Operating Requirements:
   a. The blowers provided under this section shall meet the following operating requirements:

Condition A[1]	
Inlet pressure, psia	11.8
Inlet temperature, degrees F	-11°F
Relative humidity, percent	36
Discharge pressure, psia	15.6
Mass flow rate, scfm[a]	1,416
Shaft efficiency, min., percent[3]	70
Operating condition	Throttled

Condition B[2]	
Inlet pressure, psia	11.8
Inlet temperature, degrees F	108°F
Relative humidity, percent	36
Discharge pressure, psia	15.7
Mass flow rate, scfm[a]	1,416
Shaft efficiency, min., percent[3]	70
Operating condition	Throttled
Notes:	
[a]Standard conditions (68 deg F, 14.696 psia)	

Condition C[3]	
Inlet pressure, psia	11.8
Inlet temperature, degrees F	-11°F
Relative humidity, percent	36
Discharge pressure, psia	16.5
Mass flow rate, scfm[a]	1,416
Shaft efficiency, min., percent[3]	70
Operating condition	Throttled
Notes:	
[a]Standard conditions (68 deg F, 14.696 psia)	

Condition D[4]	
Inlet pressure, psia	11.8
Inlet temperature, degrees F	108°F

Condition D[4]	
Relative humidity, percent	36
Discharge pressure, psia	16.6
Mass flow rate, scfm[a]	1,416
Shaft efficiency, min., percent[3]	70
Operating condition	Throttled

Notes:

[a]Standard conditions (68 deg F, 14.696 psia)

b. In addition, the following limitations shall apply to the motor:

Motor speed, rpm	3600
Motor horsepower, maximum[2]	100
Motor full load power factor, minimum	89.0

Notes:

1. *Condition A shall be the blower's rated condition. Because the blower will be operated at constant volume, the blower shall be selected to position Condition A as close as practicable to the best efficiency point on the blower's output pressure-capacity curve. The blower's shaft efficiency at the rated condition shall be not less than that listed.*
2. *Condition B is the estimated operating requirement for the blower under conditions which will impose the greatest mass flow through the machine. The blower motor shall be selected to drive the unthrottled blower without overloading under this condition. Use of the motor's service factor rating to meet this requirement will not be accepted.*
3. *Shaft efficiency shall be defined as the ratio of the adiabatic power for compression of a perfect gas to the power driving the blower shaft. Shaft efficiency shall be calculated in accordance with ASME PTC-13 with k, the ratio of specific heats, taken as having a value of 1.40 for air. Standard atmospheric conditions shall be taken as 68 degrees F, 14.7 psia, and 36 percent relative humidity.*

c. The blower shall have, as a minimum, 0.75 psi pressure rise to surge from the rated discharge pressure. The surge point shall be not more than 50 percent of the volume produced at Condition A.

F. Controls:

1. Each blower shall be provided with a wall-mounted control cabinet to contain the machine's start/stop controls as well as monitoring and safety/shutdown systems.

1.02 QUALITY ASSURANCE

A. Factory Tests:

1. Each blower shall be subjected to a factory test. Factory tests shall be performed in accordance with ASME PTC-10, Class II. The test shall be conducted at constant speed and shall extend from the surge point to not less than 120 percent of design volume at design pressure. The test shall be sufficiently comprehensive to produce guaranteed performance characteristics.
2. The test data shall be employed to produce operating curves showing pressure-capacity, power-capacity, and efficiency-capacity curves and surge points for each operating condition specified. Capacity shall be in inlet cfm.
3. Test logs and guaranteed performance curves shall be provided and certified by an officer of the blower manufacturer's corporation under penalty of perjury.
4. The motor shall be subjected to a factory test which shall consist of:
   a. No load current and speed

b. Locked rotor current
c. Winding resistance
d. Four-hour heat run
e. Winding and bearing temperature at end of heat run
f. Hi-pot test in accordance with NEMA MG1-20.47
g. Bearing inspection

5. The specified tests shall be performed in accordance with NEMA MG1-12 or MG1-20, as applicable. Copies of the results, plus the computer design calculation printout for efficiency and power factor (at 100 percent, 75 percent and 50 percent of full load) and locked rotor current shall be provided and certified by an officer of the motor manufacturer's corporation under penalty of perjury.

B. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AISI	Pocketbook of AISI Standard Steels
ANSI H35.1	Alloy and Temper Designation Systems
ANSI/IEEE 112	Polyphase Induction Motors and Generators
ASME PTC-10-65 (R1992)	Power Test Code for Exhausters Compressors
ASTM A36/A36M	Structural Steel
ASTM A48	Gray Iron Castings
NEMA MG1	Motors and Generators

C. Unit Responsibility:

1. The Contractor shall assign unit responsibility as specified in Section 43 05 11 to the blower manufacturer for the equipment specified in this section. A certificate of unit responsibility shall be provided.

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
4. Manufacturer's catalog data and shop drawings confirming dimensions, weight, construction, and installation details of blower and all associated equipment.
5. Predicted performance curves for the specified operating requirements under both Conditions A and B showing pressure-capacity, power-capacity, and efficiency-capacity curves and surge points. Capacity shown in inlet cfm. All performance parameters are to reflect site conditions as listed in this Section for each operating condition. Sample actual test condition inlet/specified condition acfm conversion calculations shall also be provided.
6. Predicted power-capacity (inlet cfm) curves for blowers for inlet throttled operation under Conditions A and B at inlet valve positions from 70 degrees open to 20 degrees open in 10-degree increments.
7. Operating noise levels shall be provided for the motor and blower combination. Noise shall be expressed as sound pressure levels (SPL) in decibels as read on the "A" weighting network of a standard sound level meter (dbA); all measurements shall be made in relation to a reference pressure of 0.0002 microbar.
8. Drawing and catalog information detailing all control devices in the control cabinets as well as overall panel layout interconnection diagrams and construction.
9. Spatial requirements, showing clearances required for maintenance purposes.
10. Motor data, Section 43 05 21-Form A as required in Section 43 05 21.

1.04 ENVIRONMENTAL CONDITIONS

A. Blowers to be installed under this section shall be suitable for continuous service and installation indoors at an elevation of 5315. Temperatures are expected to range between 0 and 105 degrees F in the room. Relative humidity within the room is expected to range between 23 and 80 percent.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Blowers shall be multistage centrifugal compressors as manufactured by Gardner Denver, Continental Blower, Or approved equal modified to meet specified requirements.

2.02 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Casing and bearing housing	Cast iron, ASTM A48, Class 25
Impeller	Cast aluminum, ANSI H35.1 Type 443 or fabricated aluminum, ANSI 5052-H-34
Shaft	Steel, SAE 1045 or AISI 1045
Tie rods	Steel
Base	Structural steel, ASTM A36

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 EQUIPMENT FEATURES

A. Multistage Blower:

1. The multistage centrifugal blower shall utilize single piece, cast iron, volute sections which are assembled in sufficient number with the inlet and discharge sections to provide the number of compression stages required to achieve the specified discharge pressure. The complete assembly shall be held together with high strength steel tie rods which shall connect body flanges on the suction and discharge heads. Inlet and discharge connections shall be flanged and oriented and sized as specified. The interstage sealing diaphragm shall be cast as a part of each casing inlet to each stage to ensure proper approach conditions, reduce turbulence, and improve blower efficiency. Shaft end seals shall be the carbon ring or lead babbitted labyrinth type. Interstage seals shall be aluminum labyrinth type.

2. Bearings shall be oil lubricated, anti-friction type sized for an L-10 bearing life of 100,000 hours. Bearing lubrication shall be by constant-level oilers. Bearings shall be mounted in outboard cast iron housings which shall be designed to affect a complete separation between the bearing and the casing to isolate the bearing from the heat generated by the machine. Bearings shall be replaceable without disconnecting any piping or disassembling the machine. Each bearing assembly shall be provided with a thermo-well and replaceable switch type temperature detector.
3. Impellers shall be keyed to the shaft and held in place by abutting spacers and lock washer assemblies. The rotating assembly shall be statically and dynamically balanced to limit vibration to 1.25 mil (peak-to-peak) when measured on the outboard bearing housing at design speed. Maximum rotor tip speed shall not exceed 450 feet per second. The first critical speed of the rotating assembly shall be not less than 20 percent above the operating speed.

B. Motor:
1. Each blower drive motor shall be guarded, dripproof, 480 volts, 3 phase, 60 hertz, squirrel cage induction type. The motor shall be continuous time rated in accordance with NEMA MG1, paragraph 10.35. The motor shall have a service factor of 1.15. The driven load, including shaft connected power absorbing accessories, shall not exceed the motor's nameplate rating. Insulation shall be Class F, with Class B (80 degrees C) rise based upon a 60-degree C ambient temperature. Maximum locked rotor current shall be 650 percent of full-load current. Torque rating shall conform to NEMA MG1-20.41. The motor shall be a high-efficiency design. Minimum guaranteed full-load efficiency shall be tested in accordance with IEEE 112, Method B. Rotor and stator windings shall be copper, form wound type, sealed with vacuum impregnated epoxy resin. Windings shall pass the sealed winding conformance test in accordance with NEMA MG1-20.48. The windings shall be braced to permit across-the-line full voltage starting. Two temperature detectors, embedded in the windings and wired to the motor temperature detector junction box, shall be provided for each phase. Only one detector per phase shall be wired to the temperature monitor. The motor enclosure shall be guarded, drip-proof type of cast iron or fabricated steel not less than 0.125 inches thick. Washable air filters, differential air pressure gages, and stainless steel screens shall be provided over all enclosure openings. The enclosure shall be painted, inside and out, with a chemical resistant epoxy paint. Two lifting eyes shall be provided.
2. The motor enclosure shall be provided with an anticondensation heater designed for operation on 120 VAC, single-phase, 60 Hz. The heater rating and voltage shall be noted on the motor nameplate. Maximum surface temperature shall be 200 degrees F. Space heater terminals shall be wired to a separate terminal box.
3. Bearings shall be grease lubricated, anti-friction type, sized for an L-10 bearing life of 100,000 hours. Each bearing assembly shall be provided with a thermo-well and a replaceable switch type temperature detector.

C. Base and Isolation Pad:

1. The blower and motor shall be connected through a flexible coupling and shall be mounted on a common structural steel base, which shall be designed to keep the unit in proper alignment. The structural steel base shall rest upon a one-piece cork and rubber sandwich isolation pad consisting of a high-density cork layer permanently bonded to top and bottom layers of waffle embossed, oil-resistant, synthetic rubber. The structural base and its isolation pad shall in turn be mounted upon a concrete equipment pad.

D. Accessories:

1. Inlet Valve:
   a. The inlet valve shall be an actuated control valve as specified in Section 40 05 64. The operator shall be a manual chain wheel type as specified in Section 40 05 57.13.
2. Discharge Check Valve:
   a. The blower shall be supplied with a discharge check valve suitable for use in the service specified and capable of providing an airtight seal upon closure with minimum pressure loss when open. The check valve shall be of the double disc, center pivot, spring assisted type, specifically designed and suitable for installation in the orientation shown under the operating conditions and test pressures specified. When necessary because of piping configuration or valve orientation, special lightweight discs and/or special springs shall be provided to assure proper operation and sealing or to minimize pressure loss. All components shall be suitable for use with air temperatures as great as 300 degrees F. Valves shall be APCO series 9000, Stockham Duo-Chek II, Gulf Valve Model MB, or equal, modified to meet specified requirements.
3. Coupling and Guard:
   a. Each blower shall be directly coupled to the electric motor through a dry type spacer coupling. An OSHA approved coupling guard of heavy gauge steel shall be included, bolted solidly in place.
4. Expansion Joints:
   a. Single arch, flexible rubber expansion joints as specified in Section 40 05 06.23-2.01 Elastomer and Fabric Construction shall be provided by the blower manufacturer at the suction and discharge connections to the blower.
5. Blowoff Silencer:
   1) The blower shall be provided with a discharge blowoff silencer suitable for installation as specified. The silencer shall be selected to limit noise to not more than 96 dba 3 feet from the blowoff exhaust.
   2) The blow-off silencer shall be an inline absorption type, provided with flanged connections for installation in piping as shown on the drawings. Silencer shall be Stoddard, Universal, or equal.
   3) Blow-off silencer shall be constructed of carbon steel, with manufacturer's standard epoxy coating.
   4) The blowoff silencer shall be shipped loose for installation in the blowoff piping by the Contractor.

E. Instruments:
   1. General:
      a. Each blower shall be provided with a discharge pressure gauge and a motor current ammeter.
         1) The pressure gauge shall be mounted as recommended by the blower manufacturer and as specified in this section.
         2) All blower instruments shall be field calibrated and tested under actual operating conditions by the blower manufacturer.
   2. Pressure Gauge:
      a. The pressure gauge shall comply with Section 40 73 00.
   3. Ammeter:
      a. Ammeter shall display blower motor current and be calibrated to blower capacity in scfm. The ammeter shall show surge region, design point, and maximum blower capacity corresponding to nameplate motor capacity.

F. Controls and Electrical:
   1. General:
      a. Control and electrical devices and systems shall conform to Divisions 26 and 40 of this project manual. Where 24-VDC controls are provided, two power supply transformers shall be provided for each control cabinet.
   2. Control Cabinet:
      a. The control cabinet construction shall conform to the requirements of Divisions 26 and 40 of this project manual.
   3. Monitors:
      a. The control cabinet shall contain instruments to monitor the following:
         1) Blower discharge volume, scfm (from calibrated ammeter)
         2) Elapsed time meter, hours
   4. Safety Shutdown:
      a. Safety shutdown circuits shall be provided for the following:
         1) Surge
         2) Motor overcurrent. If motor current rises to 100-percent nameplate rating, the unit shall shutdown according to the emergency shutdown sequence.
   5. Indicating Lights:
      a. Indicating lights shall be provided to indicate blower status as follows:

Ready	Green
Running	Red

2.04 SPARE PARTS

A. Spare parts shall be provided for each blower as follows:
   1. 1 set--end seals and interstage seals
   2. 2 sets--all gaskets
   3. 1 set--main bearings

4. 1 set--special tools required for maintenance, if any

B. Spare parts shall be tagged and stored in accordance with Section 43 05 11-2.12.

2.05 PRODUCT DATA

A. The following information shall be provided.
   1. Certified results of factory blower and motor tests including test logs as specified in paragraph 1.02 Factory Tests.
   2. Certified performance curves for each unit based upon pressure-capacity, power-capacity, efficiency-capacity curves, and surge points.
   3. Certification that blowers operate under first critical speed in accordance with the requirements of paragraph 2.03 Multistage Blower.
   4. Motor product data as specified in Section 43 05 21-2.05.
   5. Certified balancing test logs.
   6. Operator and maintenance information as specified in Section 01 78 23.
   7. Installation Certification Section 43 05 11-Form A specified in paragraph 3.01.
   8. Training Certification Section 43 05 11-Form B specified in paragraph 3.03.

PART 3 EXECUTION

3.01 INSTALLATION

A. The blower shall be connected and installed in accordance with the manufacturer's recommendations. Installation and alignment shall be performed by millwrights. The installation shall be certified on Form 43 05 11-A as specified in Section 01 99 90.

3.02 START-UP AND TESTING

A. The equipment provided under this section shall be started and tested only under the direction of personnel provided by the equipment manufacturer. To that end, the Contractor shall cause the manufacturer to furnish start-up and testing specialists factory trained in the proper procedures for initial installation, initial testing, and commissioning of the equipment. All such activities shall be performed under the direction of these specialists. This provision, however, shall not be construed as relieving the Contractor of overall responsibility for this work.

B. Test procedures shall conform to the requirements of Section 01 45 20 and those specified in this Section 43 11 17.16. They shall contain the following features:
   1. Static tests of all control and protective circuits.
   2. Not less than 2 cold starts.
   3. Not less than 24 hours of continuous operation at full load.

C. Commissioning shall conform to the requirements of Section 01 91 00.

3.03 TRAINING

A. The Contractor shall cause the equipment manufacturer, as a part of the commissioning services, to provide not less than 16 hours of on-the-job training. Training shall include the requirements of Section 01 79 00 and the following:
   1. Centrifugal blower theory.
   2. General operational information for the specific equipment provided under this section.
   3. Operation of the equipment in automatic and manual modes.
   4. Troubleshooting.
   5. Routine maintenance.

B. Training shall be certified on Form 43 05 11-B as specified in Section 01 99 90.

END OF SECTION

SECTION 43 23 03

GENERAL REQUIREMENTS FOR CENTRIFUGAL AND AXIAL-FLOW PUMPING EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section, when referenced in the detailed specification section, provides minimum requirements applicable to centrifugal and axial-flow pumping equipment furnished under this contract. More restrictive requirements and/or specific citation or requirement in conflict with a 43 23 03 provision, where found in individual pump specifications, supersede requirements of this section for each specific instance.
2. "Detailed pump specification," "detailed specification," "individual pump specification," "referencing section," or words of similar import in this section, mean the specification section where the requirements for specific pump performance are presented. "Pumping unit," whenever and wherever used, means the complete pumping assembly, including driver (whether engine, turbine, or motor) and includes accessories such as variable-speed drives required for motor operation, gear reducers, intermediate shafting and bearings, flywheels, and supports for equipment furnished with the pump.
3. For a subset of pumps, a number of provisions of this section are required. These requirements (refer to paragraphs 1.05 and 1.07 in this section) are in addition to requirements applicable to pumps. The subset of pumps is defined as pumping equipment meeting any of the following criteria:
    a. All pumping unit specifications where the words "custom-engineered" appear in the title of the specification section
    b. Where a particular Section 43 23 03 provision is cited in the detailed section

B. Definitions:

1. The following definitions apply for classifying pumps specified in this and referencing sections:
    a. General: Terminology and definitions in this section follow those established in American National Standards Institute (ANSI)/Hydraulic Institute (HI) 9.1 through 9.5, unless otherwise noted.
    b. Solids-bearing liquids: Liquids to be pumped containing, or assumed to contain, solids that require appropriate pump design considerations and/or materials of construction. Solids-bearing liquids are liquids with settleable solids exceeding 50 milligrams per liter (mg/L) and include wastewater, stormwater, primary effluent, return sludge, return activated sludge (RAS), trickling filter circulation, and similar services.
    c. Clear liquids: Liquids to be pumped mostly free of deleterious solids. Potable water, heat reservoir, raw water, secondary effluent pumping, and similar services are clear liquids.

d. Efficiency: For the purposes of this section and sections referencing this section, efficiency, as related to pumps, is the ratio of the pump output power (water horsepower [hp]) divided by the pump input power (brake horsepower) required to deliver the total head, with meanings as defined in ANSI/HI 14.2.6.6. For column-type pumps, efficiency is computed inclusive of inlet, bowl, column, and discharge head losses.

e. Net positive suction head, 3 percent reduction (NPSH3): For the purposes of this section and sections referencing this section, NPSH3 means the value of net positive suction head (NPSH) resulting in a reduction of 3 percent in the developed pump discharge head when the pump is tested in accordance with procedures established by ANSI/HI. NPSH3 is the successor designation to net positive suction head required (NPSHR). Where NPSHR is used in the contract documents it means NPSH3.

f. NPSH margin: For the purposes of this section and sections referencing this section, "NPSH margin," wherever used, means net positive suction head available (NPSHA) divided by the candidate pump's NPSH3 for the specific operating condition in question.

g. POR: preferred operating region as defined in ANSI/HI 9.6.3.

h. AOR: allowable operating region as defined in ANSI/HI 9.6.3.

1.02 TYPE

A. Provisions and requirements contained in this section apply specifically to centrifugal and axial-flow pumps, both vertical and horizontal, commonly falling into the generic types covered by ANSI/HI 14.1 through 14.3. This section does not apply, except by specific reference, to positive-displacement pumps of any type.

1.03 REFERENCES

A. This section (Section 43 23 03) contains references to the following documents. They are a part of this section and any referencing section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. The following order of precedence prevails in the event of conflict between the requirements of this section or any referencing section and those of the listed documents (in the order of primacy):

1. The referencing section
2. This section
3. The referenced document

B. Unless otherwise specified, references to documents mean the documents in effect at the time of advertisement for bids or invitation to bid (or on the effective date of the agreement if there were no bids). References to documents mean the replacement documents issued or otherwise identified by the organization if referenced documents have been discontinued, or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
AISC	American Institute of Steel Construction—Manual of Practice
ANSI/API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries (also referenced as ISO 13709-2009)
ANSI/ASME B46.1	Surface Texture, Surface Roughness, Waviness and Lay
ANSI/HI 9.1–9.5	Pumps – General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation
ANSI/HI 9.6.1	Rotodynamic Pumps—Guideline for NPSH Margin
ANSI/HI 9.6.2	Centrifugal and Vertical Pumps for Allowable Nozzle Loads
ANSI/HI 9.6.3	Rotodynamic Pumps (Centrifugal and Vertical) Guideline for Allowable Operating Region
ANSI/HI 9.6.4	Rotodynamic Pumps—Vibration Measurements and Allowable Values
ANSI/HI 9.6.6	Rotodynamic Pumps for Pump Piping
ANSI/HI 9.6.8	Rotodynamic Pumps—Guideline for Dynamics of Pumping Machinery
ANSI/HI 9.8	Pump Intake Design
ANSI/HI 11.6	Submersible Pump Tests
ANSI/HI 14.1-14.2	Rotodynamic Pumps for Nomenclature and Definitions
ANSI/HI 14.3	Rotodynamic Pumps for Design and Application
ANSI/HI 14.4	Rotodynamic Pumps for Installation, Operation, and Maintenance
ANSI/HI 14.6	Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
API 686/PIP REIE 686	Recommended Practices for Machinery Installation and Installation Design
ASME B18.8.2	Taper Pins, Dowel Pins, Straight Pins, Grooved Pins, and Spring Pins (Inch Series)
ASME Code	ASME Boiler and Pressure Vessel Code
ASTM A27	Steel Castings, Carbon, for General Application
ASTM A36	Carbon Structural Steel
ASTM A148	Steel Castings, High Strength, for Structural Purposes
ASTM A322	Steel Bars, Alloy, Standard Grades
ASTM A564	Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A571	Austenitic Ductile Iron Castings for Pressure-Containing Parts Suitable for Low-Temperature Service
ASTM A995	Standard Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts, Grades 2A, 3A, or 6A
ASTM B148	Aluminum-Bronze Sand Castings
AWWA C213	Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
NSF/ANSI 61	Drinking Water System Components – Health Effects
IEC 61298-2	Process Measurement and Control Devices. General Methods and Procedures for Evaluating Performance Tests Under Reference Conditions
ISO 1940-1:2003	Mechanical Vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances
ISO 9001	Quality Management Systems—Requirements, 3rd Edition (2000)
ISO 10816-1	Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 1: General Guidelines, Annex B, Table B.1. Class I, II or II, as applicable. For the purposes of this specification, Annex B of ISO 10816, Part 1 forms a part of this specification and ISO 10816, Part 1.

Reference	Title
ISO 10816-3	Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ, Annex A, Table A.1 and A.2. For the purposes of this specification, Annex A of ISO 10816, Part 3 forms a part of this specification and ISO 10816, Part 3.
ISO 10816-6	Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 6: Reciprocating machines with power ratings above 100 kW, Annex A, Table A.1, machine vibration classification number 3. For the purposes of this specification, Annex A of ISO 10816, Part 6 forms a part of this specification and ISO 10816, Part 6.
ISO 10816-7	Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 7: Rotordynamic Pumps for Industrial Applications, Including Measurements on Rotating Shafts, Annex A, Tables A-1 and A-2 Category II as applicable. For the purposes of this specification, Annex A of ISO 10816, Part 7 forms a part of this specification and ISO 10816, Part 7.

1.04 DESIGN REQUIREMENTS, ALL PUMPS:

A. General:

1. Equipment furnished under sections referencing this section shall meet the longevity objective that the pumping equipment, motor, shafting, couplings and appurtenances are designed for at least a 20-year service life and 3 years of “uninterrupted operation.” Select all components associated with the rotating elements in the drive train, including equipment supports and supports for rotating elements, that are designed to function without damage or disassembly at reverse rotational speeds up to 130 percent of maximum operational speed during flow reversals through the pump. The complete pumping unit shall operate without overload on any component at any point along the pump’s entire full-speed operating curve. Furnish pumps required by virtue of the specified operating conditions to operate against a closed valve or throttled for any period of time exceeding 5 seconds with drivers sized to operate continuously at the power requirement for that condition even though the power requirements at the rated condition may be less.
2. Pump selections proposing maximum diameter impellers for the proposed pump model and casing size will not be accepted.
3. With the exception of submersible pumps and the inlet connection for pumps designed to operate in open forebays or wetwells, pump connection nozzles shall be designed for the loads and moments stipulated in ANSI/HI 9.6.2. Where ANSI/HI 9.6.2 does not cover a specific pump type or category, or where that document is silent on allowable nozzle loads or a particular type of nozzle load (e.g., thermal pipe strain), the contractor shall furnish documentation from the manufacturer attesting to the limitations on loads and moment forces that can be tolerated on each connection and recommended connection details to be used.

B. Pump Selection:
   1. Proven designs:
      a. Pumps furnished under sections referencing this section shall be proven designs that have been in similar conditions of service with no objectionable performance characteristics for a period of not less than 5 years. The contractor shall furnish a detailed list of installations with contact information supporting qualification under this requirement with the information required under paragraph 1.08. To satisfy this requirement, the listed pump shall be of the same size volute or bowl, discharge case and nozzle size, and impeller design (including number of vanes) and is operating under similar conditions of pumped fluid, head, capacity, speed, rotation, and NPSHA.
      b. The contractor may propose alternative equipment that cannot meet the requirement for a proven design under this paragraph, subject to additional documentation requirements and under the following conditions:
         1) The proposed design has been in successful operation under similar conditions of volute or bowl, discharge case and nozzle size, impeller design (including number of vanes), pumped fluid, head, capacity, rotation, and NPSHA, but at a higher speed for a period of not less than 3 years.
         2) The proposed design has been in operation in designs where both larger and smaller nozzle size pumps have been in service for a period of not less than 5 years, and impeller design (including number of vanes, plus or minus one vane in pumps with four or more vanes), pumped fluid, head, capacity, speed, and NPSHA are similar to that for the proposed installation and within one synchronous speed higher or lower than that indicated in the detailed specification.
         3) In addition to the installation list required under this paragraph, provide dimensional drawings, bill of materials, and historical (certified) shop test results for candidate pumps documenting performance including, but not limited to head, capacity, speed, and NPSHR, and limit of stable hydraulic operation based on the onset of suction recirculation, if available. Results should match or bracket the specified performance and two or more candidate pump results may be required.
      c. If the proposed pump is not a proven design under either of the above paragraphs, the contractor shall demonstrate, by operation of a test pump in a fully equipped hydraulic test facility, that the proposed pump in the size and at the speed proposed with the proposed impeller design will have acceptable operating characteristics under the conditions specified for the proposed installation. Set up the test pump and perform a witnessed demonstration prior to designing, fabrication, and testing of any of the equipment proposed for the specific installation.
   2. General performance criteria:
      a. Pumps furnished under this section and any referencing section shall operate without loss of head due to cavitation or vibration over the entire specified range of flow and head conditions and are specifically selected for NPSH margin requirements detailed in paragraph 1.04 NPSH margin limitations. Pump selections that do not provide the specified margin will be rejected.

3. General design criteria:
    a. Select pumps furnished under sections referencing this section that are designed in accordance with applicable portions of ANSI/HI 9.6.2, 9.6.3, 9.6.4, 9.6.6, 9.6.8 and 14.1-14.3 and the requirements of this section. Select pumps that are specifically designed to pump the fluid described in the detailed specification and to operate without clogging or fouling caused by material in the pumped fluid at any operating condition within the range of service specified. Clogging or fouling conditions may be of any cause, demonstrated by a 5 percent or greater capacity drift within 2 hours of sustained operation.
    b. Unless otherwise noted or specified, slope pump head capacity curves in one continuous curve within the specified operating conditions. Do not permit points of reverse slope inflection capable of causing unstable operation within the specified zone of continuous-duty operation. Pumps with head/capacity curves with a reverse inflection are specifically prohibited if these characteristics will cause unstable operation within the specified range of operating conditions and where startup/shutdown conditions entail operation against a slow opening/closing valve.
    c. Column-type (vertical-turbine, vertical-column solids-handling, and axial-flow propeller and mixed-flow) pumps shall have bells selected to provide intake velocity of not less than 3.5 feet per second (ft/s) or more than 4.0 ft/s when operating at the maximum specified flow or the flow resulting from the lowest specified operating head at maximum speed, whichever is greatest (“peak flow”). Pump discharge column sizes shall limit the calculated average velocity at peak flow to no more than 12 ft/s.
    d. Pumps specified to operate at constant-speed shall function without loss of head or capacity due to cavitation or excessive vibration over the entire specified range of flow and head conditions defined by the region bounded by Condition Points A, B, and C and any other continuous-duty operating condition specified in the detailed specification referencing this section. In addition, constant-speed pumps shall be selected to place Condition Point C in the detailed specification within the POR, or a modified POR if stipulated in the detailed pump specification.
    e. Pumps specified to operate at variable-speed shall function without loss of head or capacity due to cavitation or excessive vibration over the entire specified range of flow and head conditions defined by the region bounded by Condition Points A, B, and C and any other continuous-duty operating condition specified in the detailed specification referencing this section. Unless otherwise specified in the section referencing this section, acceptance criteria shall include the following:
        1) Operating Condition Point C and any other continuous-duty operating point specifically required in the detailed specification shall reside within the region defined by the POR, or in a modified POR if stipulated in the detailed pump specification.
        2) Unless otherwise noted in the detailed specification referencing this section, Operating Condition Point A may reside in the AOR outside the POR; Condition Point C will be located within the POR, or in a modified POR if stipulated in the detailed pump specification; and Condition B will preferably be located within the POR, or within 5 BEPQ percentage points (in terms of flow) outside the POR so long as Condition Point C resides in the POR or the stipulated modified range.

4. POR:
    a. Unless otherwise specified, the POR for a given pump is as defined in ANSI/HI 9.6.3.
    b. The detailed specifications may stipulate a narrower POR than indicated in ANSI/HI 9.6.3.
    c. The suction-specific speed (S) shall not exceed 8,500, unless otherwise indicated in the detailed specifications.
    d. For high- S pumps (greater than 8,500) and other conditions as determined by the engineer, a narrower stable operating region may be defined in the detailed specifications and then identified in ANSI/HI 9.6.3 for the POR. The detailed specifications take precedence over this section.
    e. The detailed specification sections identify the duty points that must be within a pump's POR and those that may be within the AOR and take precedence over this section.

C. Critical Speeds and Natural Frequencies:
    1. General:
        a. The criteria of this paragraph applies to pumps, provided that the foundation and support details provided at the time of pump design are accurate. Repair or replace pumps exhibiting adverse behavior after installation from resonance, vibration, or fatigue at no cost to the owner. The criteria apply to the equipment in "like-new" condition as well as the "as-worn" condition (i.e., when parts, individually and as a composite, reach the manufacturers' maximum tolerances). Critical speed and natural frequency data submittal requirements depend upon the pump:
            1) For the more critical pumps that are covered under paragraph 1.05, and other pumps covered under paragraph 1.04 Alternate mass elastic design, where specified in the detailed specification section, the contractor is required to submit analytical reports confirming requirements on critical speeds and natural frequencies prior to pump fabrication, as specified
            2) Unless otherwise specified, for constant-speed pumps and variable-speed pumps with suction size less than 6 inches diameter, no critical speed submittal is required
            3) Except as modified in paragraph 1.04 Alternate mass elastic design, the requirements of 1.05 Critical Speed Analysis and System Design apply to other pumps, where specified in the detailed specification section.

    2. Alternate mass elastic design:
        a. Subject the complete pumping unit (including rotating elements, frames, and supports) and related structural elements (including pump, motor, and bearing supports) to structural, lateral, and torsional dynamic analyses, per ANSI/HI 9.6.8 Level 2 and as follows:
            1) Select the complete pumping unit rotating group including pump, motor, intermediate shafting and flywheel rotors (if specified), and other elements in the power train (or powered via the power train) that are designed and manufactured to limit torsional stresses.

2) Additionally, for vertically suspended (VS) and vertically mounted overhung (OH) and between bearing (BB) types provide pump structural natural frequency analysis by modal finite element analysis (FEA)

3) Motors for vertical pumps, subjected to Level 2 analyses shall be subjected to bump test requirements under paragraph 1.04 Motors for custom-engineered pumps.

b. Professional qualifications:

1) The contractor shall require the manufacturer of the pumping equipment to provide the required analyses either with a qualified design professional employed by the manufacturer or a person employed by an independent firm that may have other contract relationships with the pump manufacturer.

2) Aside from allowing the qualified design professional to be employed by the manufacturer or an independent firm that may be contracted to manufacturer, all other qualifications requirements of paragraph 1.05B.2 Professional qualifications apply. Provide a letter, signed by an officer of the manufacturer, describing the role of design professional and relationship to the manufacturer, in lieu of notarized certification.

c. Reports, calculations and recommendations:

1) All documentation shall be provided as specified in paragraph 1.05.

2) A field torsional vibration test is required.

d. Methodology:

1) Conduct analyses in accordance with paragraph 1.05 Lateral rotor and structural dynamic analyses, except as noted:

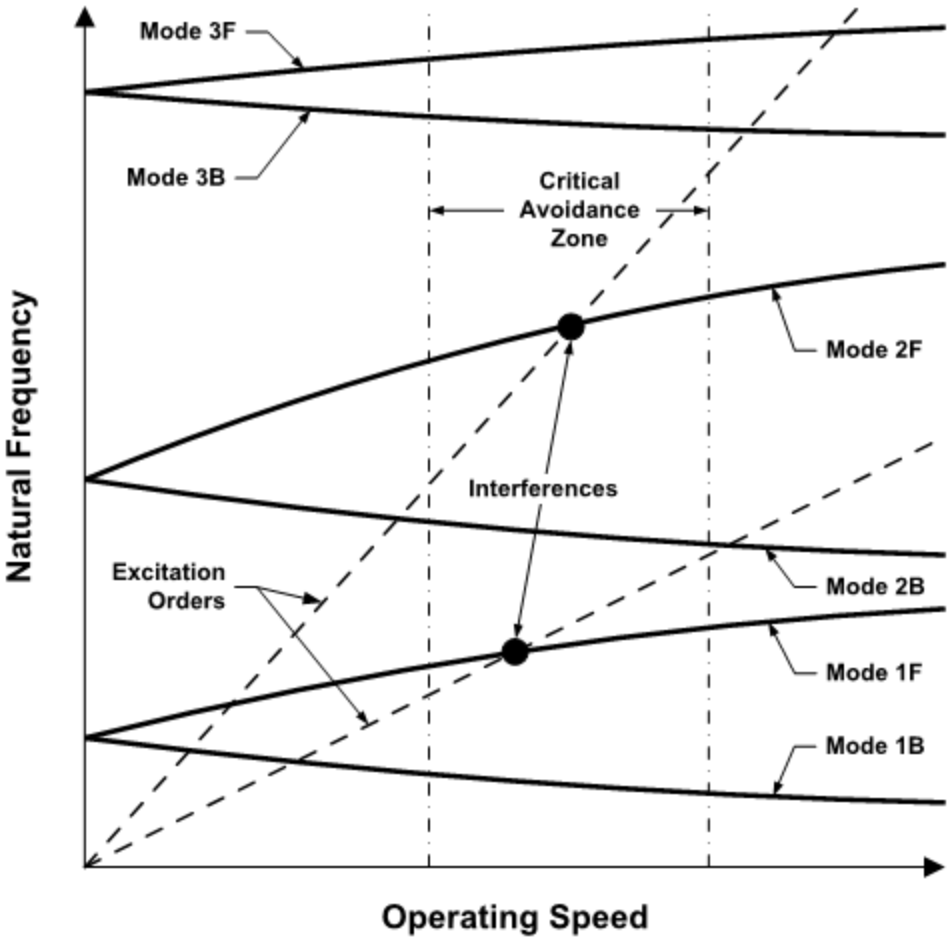
a) Analyses based on a Level 2 analysis prescribed in ANSI/HI 9.6.8:

b) Mathematical calculation tools in compliance with ANSI/HI 9.6.8, as selected by the design professional.

2) In case of conflict between these specifications and ANSI/HI 9.6.8, these specifications shall prevail (e.g., Campbell diagrams shall be provided), unless an exception is requested by the Contractor and approved by the Construction Manager.

3. Lateral rotor and structural dynamics:

a. The complete pumping unit, composed of the entire rotating group and related frames, supports, enclosures, housings, and casings, shall be free from critical speeds from 15 percent below to 25 percent above the operating speeds required to achieve the specified performance characteristics (critical avoidance zone). A critical speed is defined as any damped natural frequency with a logarithmic decrement less than +0.3 that has an interference with a primary excitation order in the critical avoidance zone. Analyze backward rotation for rubber-bearing vertical-column pumps. The critical avoidance zone, interferences, and possible critical speeds can be illustrated on a natural frequency map as presented in the figure below. In the figure, three natural frequencies are shown with forward and backward modes. Only two of those modes, 1F and 2F, have interferences with primary excitation orders. Whether these are critical speeds is determined by the value of log decrement at the intersection. Note that higher order modes, such as 2F, have the same log decrement criterion as the first mode.



b. Process sensitivities are such that operation at infinitely variable speed within the specified operational conditions is an absolute requirement. Any remedy imposing a locked-out speed interval or intervals will not be considered an acceptable remedy for identified critical speeds. Acceptable remedies include combinations of adjustments in rotor geometry or materials, and the substitution of energy-absorbing couplings. Other remedies may be considered so long as they are justified in writing and the proposal is sealed and signed by the design professional retained by the manufacturer to perform the system mass elastic system analyses.

4. Torsional rotordynamics and combined shaft stress:

a. The complete rotating group shall be free from critical speeds from 10 percent below to 20 percent above the operating speeds required to achieve the specified performance characteristics (critical avoidance zone). A critical speed is defined as any damped natural frequency with a logarithmic decrement less than plus 0.3 that has an interference with a primary excitation order in the critical avoidance zone.

b. If efforts to remove torsional critical speeds are unsuccessful, perform a combined shaft stress analysis to demonstrate that the response does not adversely affect the entire rotating group fatigue life. The combined shaft stress analysis shall consider any speed in the critical avoidance zone and during startup, shutdown, or motor control transients if synchronous motors are specified.

c. For constant-torque applications, the pump-rotating group shall be free from torsional response that produces combined (steady plus alternating torque induced) stresses exceeding 50 percent of the material's fatigue limit or 30 percent of the material's elastic limit (but no more than 18 percent of the material's ultimate tensile strength) if relevant fatigue data for the selected material are not available.

d. For variable-torque applications (including variable-speed pumps, vertical pumps, and pumps with large overhung loads) the pump rotating group shall be free from torsional response that produces combined (torsional steady and alternating) peak shear stresses at points of stress concentration (calculated in accordance with the requirements of paragraph 1.04E.3 Torsional Shaft Stresses) that exceed 50 percent of the material's fatigue limit or 4 percent of the material's ultimate tensile strength, based upon ASME or other recognized standard, if relevant fatigue data for the selected material are not available.

e. Document the source of fatigue data used in lieu of elastic or ultimate strength ratios in the analysis report submittal.

D. Impeller clearances, vane-passing frequency, and impeller keyways:

1. The radial clearance between the tip of the impeller vane and diffuser or volute vanes shall be not less than 3 percent and 6 percent, respectively, of impeller diameter. Select a pump that is designed so that internal geometry does not cause uneven flow distribution at impeller vane inlets.

2. Impeller vane combinations shall not be an even multiple of diffuser vanes in column-type pumps.

3. Cut impeller keyways for multistage column-type pumps at differing positions and provide equal angular spacing on the impeller shaft to avoid multiple simultaneous vane-passing pulses.

E. Component design criteria:

1. General:

a. Unless otherwise specified, ensure that combined stresses in steel frames and supports does not exceed those permitted by the American Institute of Steel Construction (AISC) Manual of Practice. Combined stresses in cast, forged, rolled, or fabricated pressure-retaining components, frames, and supports shall not exceed that allowed for the given material in Section VIII, Division 1 of the American Society of Mechanical Engineers (ASME) Code. Design pressures for pressure-retaining parts shall be not less than 50 percent greater than the pump's shutoff head at the manufacturer's listed maximum operating speed. The pump casing strain at any head on the full-speed operating curve (including allowances for increases caused by specified multistage applications) shall not result in distortions at the bearing housings greater than the maximum allowable by the bearing manufacturer to provide the specified bearing life.

b. The term “combined stresses” in this section means the sum of operating stresses, including stresses induced by dynamic and static forces as developed via the analysis procedures stipulated in this section. Static forces (x, y, z, and moments in planes) include the relevant maximum nozzle loads specified in ANSI/HI 9.6.2 or as stipulated by the pump manufacturer. Dynamic forces include both steady-state and transient stresses induced by operating conditions within the zone of operation established by the specified operating conditions.

2. Anchorage and equipment mounts:
   a. The contractor shall hold the pump manufacturer responsible for the design of the anchor-bolting system and equipment supports for each separately mounted component furnished under the detailed specification. Conform anchorage and equipment support requirements for pumps to the requirements of Section 43 05 13.
   b. Select anchor bolts and connecting bolts for pumps and assemblies supported by other assemblies furnished under this section, or sections referencing this section, that are designed in accordance with Section 01 73 24. All operation and maintenance (O&M) manuals for pumps and assemblies shall contain criteria for anchor and baseplate bolt torque values.
   c. Equipment mounts for vertical (column- and volute-type) pumps weighing more than 1,000 pounds, with discharge nozzles 6 inches in diameter and greater, shall employ soleplates conforming to the requirements of Section 43 05 13. Provide soleplate mounting conforming to Section 43 05 13 for separately supported components in the pump drive system. Fabricated steel supports regardless of design, and the nature of the structural shapes used for such proposed supports, will not be accepted.
   d. Soleplates shall be designed to span openings for equipment connections and provide access to maintenance points. Soleplates shall be of sufficient section to key, not less than 1 inch, into the supporting grout provided for bonding the soleplate to the structure. Provide soleplates of sufficient size to bolt the pump base to the soleplate without encumbering the anchor bolts required for clamping the soleplate to the structure.
   e. Equipment mounts for horizontal pumps shall be designed in accordance with Section 43 05 13 and ANSI/HI 14.3, and shall provide common support for the pump and motor (and flywheel, if one is specified). Conform baseplate bolting to assumptions contained in ANSI/HI 9.6.2
   f. Use tapered dowel pins when required in the detailed specification to record the final position of machine bases on soleplates or pump baseplates. Where specified, harden and machine-ground dowel pins, conforming to the requirements of ANSI/ASME B18.8.2. Conform holes for tapered dowels to the requirements set forth in Appendix A of ANSI/HI B18.8.2.

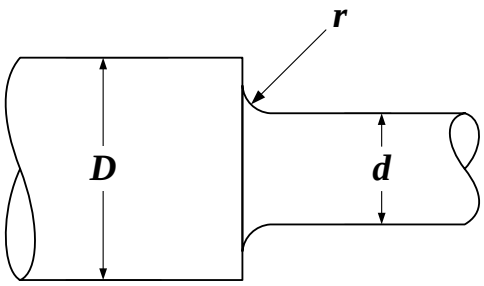
3. Torsional shaft stresses:
   a. Calculate shaft stresses using the following equation and the stress concentration factors in the tables below:

$$S = S_{cf} \times \frac{G \times D \times \Delta_{\Theta}}{2 \times L}$$

where:

S	=	stress, pounds per square inch (psi)
S_{cf}	=	stress concentration factor, dimensionless
D	=	minimum shaft diameter at point of concentration, inches
Δ_Θ	=	twist in shaft between adjacent masses, radians
L	=	effective length between masses, inches
G	=	shear modulus of shaft material, psi

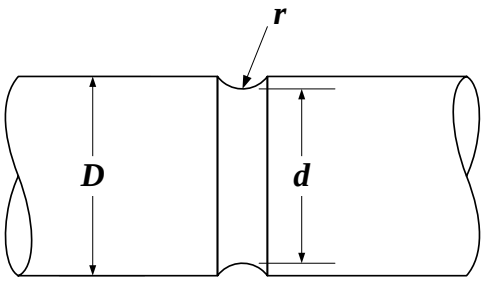
b. S_{cf} shall be applied at changes in shaft diameter is as follows:



Shaft diameter ratio D/d = 1.05	
r/d	S_{cf} [a]
0.0025	2.67
0.0100	1.84
0.0200	1.58
0.0300	1.47
0.0400	1.39
0.0500	1.34
0.1000 and greater	1.22

Shaft diameter ratio D/d = 1.50	
r/d	S_{cf} [a]
0.0025	4.05
0.0100	2.54
0.0200	2.07
0.0300	1.85
0.0400	1.72
0.0500	1.62
0.1000 and greater	1.40

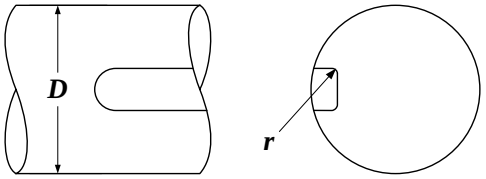
c. Ensure that the S_{cf} to be applied at circumferential shaft grooves is as follows:



Shaft diameter ratio D/d = 1.05	
r/d	S_{cf} [a]
0.0025	3.73
0.0100	2.34
0.0200	1.92
0.0300	1.74
0.0400	1.64
0.0500	1.57
0.1000 and greater	1.39

Shaft diameter ratio D/d = 1.30	
r/d	S_{cf} [a]
0.0025	5.04
0.0100	2.82
0.0200	2.24
0.0300	1.99
0.0400	1.84
0.0500	1.73
0.1000 and greater	1.49

d. Ensure that the S_{cf} to be applied at the roots of keyways is as follows:



r/D	S_{cf} *
0.0025	4.35
0.0100	3.20
0.0200	2.64
0.0300	2.43
0.0400	2.32
0.05 00	2.25
0.1000 and greater	2.12

** Base values of S_{cf} between data points in the tables above upon a straight-line interpolation.*

4. Shaft deflection:
   a. Select pump shafts installed on volute-type pumps to provide sufficient stiffness to operate without distortion or damaging vibration throughout the range of service specified. Limit shaft deflection at the face (impeller side) of the shaft seal to no more than 2 mils at any operating condition within the zone described by the specified continuous-duty operating conditions. Calculate deflection at the shaft seal as required by provisions set forth in ANSI/HI 14.3.

5. Bearings:
    a. Unless otherwise specified, select anti-friction bearings for pumps for a minimum L–10 life of 50,000 hours in accordance with ABMA 9 or 11. Ensure that anti-friction bearings for custom-engineered pumps have bearings selected for an L–10 life of 100,000 hours in accordance with ABMA 9 or 11. Select bearings for other elements in the rotating system such as motors, intermediate shaft bearings, and flywheel bearings using the same criteria as specified for the pump. Base bearing selection upon the worst combination of continuous-duty operating conditions specified and include both steady-state and transient loads. Provide calculations supporting the selection of bearing sizes as and informational submittal.
6. Bearing isolators:
    a. Unless otherwise specified, fit pump and motor bearings with bearing isolators, specifically selected for the size and type of bearing. Provide bearing isolators that are the labyrinth, non-fretting type designed to expel contaminants by centrifugal force and prevent the escape of lubricants. Provide vapor-block capability. Bearing seals shall be Inpro/Seal, or an approved equal.
7. Pump shaft seals:
    a. Unless otherwise specified in the detailed specification, pump shaft seals must be mechanical seals as specified in Section 43 05 11.

F. NPSH margin limitations:
1. General:
    a. Pumps furnished under this section and sections referencing this section shall be selected for NPSH margin limitations using the criteria set forth in this section. Base NPSH3 characteristics for the candidate pump upon documented test data not more than 5 years old. Perform testing on a pump not more than two nominal pump diameters larger or smaller than the proposed pump with an impeller of the same geometry as that proposed for the pump to be used for the subject application, and operating at either the same speed as the pump for the proposed application or a speed that provides plus or minus 10 percent of the impeller inlet velocity if reduced-speed testing is used. For very large pumps that cannot be accommodated in the manufacturer's test pit, the use of a model pump, sized in accordance with ANSI/HI 14.6, Appendix K, is acceptable. The contractor shall document the basis for pump selection based upon NPSH margin limitations as set forth in this paragraph.

b. The detailed specification sections provide NPSHA information for anticipated operating conditions for each application. This information is generally referenced to a specific elevation, stated in terms of project datum. The contractor is responsible for requiring the pump manufacturer to adjust the NPSHA information in the specification section to the elevation of the pump impeller eye for the specific pump model and size proposed for the application. NPSH3, as used in the following paragraphs, means the NPSH3 at the impeller eye, determined in accordance with ANSI/HI 11.6 or 14.6, as applicable for the proposed pump. The contractor shall require the pump manufacturer to document the method used to determine NPSH3 for the proposed pump and justifying compliance with the NPSH margin limitations established under this paragraph for each specified operating condition in material submitted under paragraph 1.08. Include in the documentation justification of the NPSH3 tests used to develop NPSH3 characteristics, including the following:
   1) Date, test procedure, and test logs of original NPSH3 information used to project requirements for the pump selected for the application
   2) Test pump size, impeller diameter, impeller model, eye diameter, and speed
   3) Calculations projecting NPSH3 test information to NPSH3 curve information for the pump proposed for the application
   4) Calculations demonstrating compliance with the NPSH margin requirements established in this paragraph

c. The contractor shall submit the manufacturer's margin calculations justifying the proposed pump selection with the material required under paragraph 1.08. The NPSH margin ratios specified in this paragraph are the minimum acceptable margin ratios. If the proposed pump requires greater margin ratios to operate within the specified operating conditions without loss of head due to cavitation, then it is the responsibility of the contractor to bear costs associated with achieving the required margin ratio by lowering the elevation of the pump setting, lowering the elevation of the structure, or through other means. Subject any such adjustments to review and acceptance by the construction manager if necessary.

d. Individual restrictions are applicable to NPSH margin depending upon the type of pumping equipment and the fluid to be pumped as set forth in ANSI/HI 9.6.1, Table 9.6.1.5.5. Under no circumstances may the absolute value of the NPSH3 margin be less than 3.5 feet.

G. Electric Motors:

1. General:

   a. Pumps shall be electric-motor driven unless otherwise specified. Select all motors to be non-overloading at any operating point along the pump's full-speed operating curve, including points located beyond specified operating conditions. Motors shall be capable of carrying the axial/radial load applied to the motor shaft with motor bearing life equivalent to the pump bearing life.

   b. All vertical motors shall be solid-shaft construction. Hollow-shaft motors will not be accepted.

   c. Motors furnished with pumps specified for operation at variable-speed shall be inverter-duty types conforming to the requirements of Section 43 05 21 and shall be compatible with the variable-speed equipment furnished with the pump.

   d. Protect motor bearings with bearing isolators as specified in paragraph 1.04.

2. Motors for custom-engineered pumps:
    a. In addition to the information submitted under the requirements of Section 43 05 21, the contractor shall provide certified reed-frequency calculations for both the motor rotor and frame for vertical motors driving custom-engineered pumps with the data to be submitted under paragraph 1.08. Upon completion of construction of motors for custom-engineered pumps, give each rotor and frame and the completed assembly a bump test to confirm reed-frequency calculations in the dynamic analysis modeling work performed under paragraph 1.05. Provide the results of the bump test, certified by the chief engineer or individual in responsible charge of the test facility, as an informational submittal under paragraph 1.08.
    b. All vertical motors shall meet motor face dimension tolerances as follows:

Motor face bolt circle diameter, inches	Motor face runout, inches
12	0.002
16.5–24.5	0.002
30–42	0.003
42 and larger	0.005

    c. The motor face register concentricity, referenced to the shaft centerline, shall be not greater than 0.002 inch if the motor is furnished without jack screws. The motor shaft total indicated runout (TIR) shall not exceed 0.002 inch.
3. Balance:
    a. Motors rated 50 hp or greater and motors driving custom-engineered pumps shall be precision-balanced, conforming to a balance grade of G2.5 per International Organization for Standardization (ISO) 1940-1.
    b. The contractor shall provide certified balance logs attesting to achieving these requirements and submitted as required by paragraph 1.08. The chief engineer or person in charge of the test facility shall sign the balance logs.

1.05 ADDITIONAL DESIGN REQUIREMENTS

A. Scope:

The following paragraphs present requirements that apply to only some pumps on the project. In each of the paragraphs, the first sub-paragraph titled “General” explains when the paragraph applies.

B. Critical Speed Analysis and System Design:
1. General:
    a. The requirements of this paragraph apply to pumping equipment in detailed specifications where the words “custom-engineered” appear in the title of the specification section, and elsewhere when the referencing specification section stipulates. Apply the analyses to the equipment in “like-new” condition, as well as the “as-worn” condition (i.e., when parts, individually and as a composite, reach the manufacturers’ maximum tolerances). For the purpose of these analyses, define worn conditions as two times the new condition clearance unless specified less by the manufacturer and specifically accepted by the construction manager.

2. Requirements:
    a. Subject the complete pumping unit (including rotating elements, frames, and supports) and related structural elements (including pump, motor, and bearing supports) to structural, lateral, and torsional dynamic analyses to identify and eliminate critical speeds as defined in paragraphs 1.04C.3.a Lateral rotor and structural dynamics and 1.04C.4.aTorsional rotordynamics and combined shaft stress.
    b. Select the complete pumping unit rotating group including pump, motor, intermediate shafting and flywheel rotors (if specified), and other elements in the power train (or powered via the power train) that are designed and manufactured to limit torsional stresses.
    c. Overhung shaft pumps and between bearings pumps operating in single-volute casings shall be subject to analysis for shaft deflection in accordance with the terms of this section.
    d. The structural, lateral, and torsional dynamic analyses together are termed the pumping equipment's "mass elastic design." No fabrication work on any component for the equipment specified under this section and any referencing section shall be started until the mass elastic design has been completed and has been reviewed by the construction manager.
    e. If the contractor proposes the use of alternative methods for the required analyses, submit documentation justifying the substitution. Include in the documentation justification that product results will be equivalent to that specified and with an equivalent level of accuracy. Also include the location and description of projects of an equivalent size where the procedure has been employed and the length of time these projects have been in actual service.
3. Professional qualifications:
    a. The contractor shall require the manufacturer of the pumping equipment to retain the services of an independent professional engineering firm, employing a qualified design professional who has been engaged in performance of the required mass elastic design analyses for not less than 10 years on equipment of similar size and complexity. The design professional shall have not been in the employ of any pump manufacturer for a period of not less than 10 years from the date of the request for proposals for the project. The design professional's firm shall submit a notarized certification attesting to having no contractual arrangements (other than for similar critical speed analysis) with the proposed pump manufacturer. The pump manufacturer's internal engineering organizations, regardless of qualifications, are specifically prohibited from doing this work. This provision, however, is not to be construed as relieving the contractor of overall responsibility for this portion of the work.
    b. The mass elastic design shall be the product of a design professional, registered to practice mechanical engineering in at least one of the states composing the United States, who has been responsible for the design of not less than five systems similar to that specified in the detailed specification section. The design professional shall have been engaged in this type of analysis for not less than 10 years, and directly supervise the performance of the work and be responsible for analysis of results and recommendations for any corrections to the specific rotating system and the associated frames and supports. The contractor shall submit the design professional's qualifications as a part of the initial submittal information required under this section.

c. The owner and construction manager believe that the following firms are capable of providing services that will satisfy the requirements of this paragraph. This statement, however, is not to be construed as an endorsement of a particular firm; do not assume that a named firm's standard service will comply with the requirements of this section. Candidate firms performing these analyses satisfactorily in the past include:
   1) DynaTech Engineering Incorporated, Auburn, California
   2) Engineering Dynamics Incorporated, Houston, Texas
   3) Xdot Engineering and Analysis, Charlottesville, Virginia
   4) Mechanical Solutions, Inc., Whippany, New Jersey

d. The contractor may propose a firm other than those listed. However, before a substitute firm can perform the analyses, submit the proposed firm's qualifications, the qualifications of personnel proposed for assignment to this project, along with examples of analyses performed on similar pumping equipment using procedures similar to those specified in this section, for review by the construction manager. Examples include the types of graphical displays required under this section as well as a complete report describing the analyses performed and the recommendations arising out of the analysis results. The construction manager retains the right to reject any proposed firm with justification.

4. Reports, calculations, and recommendations: All reports, calculations, and recommendations resulting from the required analyses shall bear the design professional's original signature and professional registration seal. Submit all reports, recommendations, and calculations produced under this paragraph under the requirements of this section, as follows:
   a. Following completion of the pumping equipment's mass elastic design, the contractor shall require the design professional to prepare a plain-English "Executive Summary" report with a narrative including a description and assumptions about the proposed operating system, detailed description of the analysis process, results of analyses and findings, detailed recommendations for modification of the pumping unit (defined in paragraph 1.01A Scope), if any, and sufficient graphical depictions to describe the information to a lay reader. Detailed calculations and extensive data reports are not to be submitted at this time and will cause the entire report to be rejected, if included. Submit this Executive Summary for review and acceptance prior to pump or component fabrication. The Executive Summary report shall state that analysis procedures have complied fully with the requirements of this section and that the proposed system will meet of the requirements set forth herein for limitations in stresses, deflection, and fatigue limits. The design professional shall affirm in writing that requirements of this section have been achieved or specifically state where exceptions have been taken, with justification citing recognized authorities for taking such exceptions. The reports shall be signed and sealed by the design professional, as specified.

b. Following review and approval of the Executive Summary report, the contractor shall require the design professional to review and address any comments from the construction manager and incorporate changes that may be required. Subsequently, the contractor shall direct the design professional to issue a complete “Final Report” with a revised Executive Summary report, recommendations binding on the manufacturer, calculations, data, and other supporting information. The format and documentation for this report shall follow the requirements of ANSI/HI 9.6.8 Appendix G Level 3 as indicated in the detailed specifications. The contractor shall submit this report as an informational submittal.

c. Upon completion and receipt of certified results of the bump tests required for the motor rotor, frame, and assembly specified under paragraph 1.04G.2, the design professional shall review the data and submit a “Supplemental Report,” as an informational submittal, either accepting the test results or recommending alterations to assembly structures to adjust for differences between calculated values used for the original analyses and actual values determined subsequent to motor fabrication.

d. Upon completion of installation and as a part of the initial test procedures specified under Section 01 45 20, the design professional responsible for the mass elastic design shall visit the site and inspect the installed equipment. Prior to the initiation of any field tests, the design professional shall issue a report attesting that the equipment, as installed, conforms to the recommendations contained in the report setting forth the results of the mass elastic system design or recommendations for remedies should the supplied equipment contain features or characteristics deviating from the original recommendations and calculations.

e. During initial testing of the equipment, the design professional shall be prepared with necessary monitors, instruments, and recorders, and shall conduct an in situ torsional vibration test on one of the installed pumping units, to be selected by the construction manager, to confirm the torsional natural frequency results of the original mass elastic system design. Conduct the torsional vibration test with transducers suitable for narrow-band spectrum analysis, including strain gauges, magnetic or optical pulse demodulation, or shaft position encoders. If the torsional vibration test should reveal any anomalies that cause the equipment to be out of compliance with the requirements of this section, the design professional shall conduct torsional vibration tests on other like pumping units and submit a comprehensive report, sealed and signed as specified above, detailing the reasons for failure to comply with these specifications and recommendations for attaining compliance. The design professional shall consider feasible options for compliance and provide detailed descriptions of the modifications required to achieve the required performance. The contractor shall implement those recommendations accepted by the Construction Manager at no cost to the Owner.

5. Methodology:
    a. Lateral rotor and structural dynamic analyses:
        1) Include in the analyses procedure the following features based on an ANSI/HI 9.6.8 Level 2 analysis and ANSI/HI 9.6.8 Level 3, with exceptions as specified in 1.04 Critical Speeds and Natural Frequencies, as prescribed in ANSI/HI 9.6.8:
            a) The procedure considers speeds required to operate the equipment within the envelope of continuous-duty operating conditions specified in paragraph 1.04C.3.a Lateral rotor and structural dynamics.
            b) The procedure includes liquid influences (wet conditions) including Lomakin effects, impeller-diffuser destabilizing forces, and added mass due to entrained fluid in the calculation of natural frequencies and forced response for pump types.
            c) The procedure produces Campbell diagrams for the proposed operating conditions depicting potential sources of excitation to check interference with relevant natural frequencies from both lateral and structural analyses. Primary excitation orders to be considered during the analysis include 1- and 2-times running speed, vane-passing frequencies for the pump impeller/cutwater-diffuser vane combinations, and any unique harmonic of running speed produced by the pumping system, up to, and including, not less than 6 times operating speed.
            d) For pump types except column pumps, the procedure considers the effect of support stiffness on natural frequencies. The range of stiffness to be considered is not to be less than 4 orders of magnitude. Results are provided in a critical-speed map (graph of natural frequencies versus stiffness similar to Figure 9.6.8.6.2.1.3 in ANSI/HI 9.6.8) and indicate the expected values of stiffness.
            e) For column-type pumps only, the procedure considers the effect on critical speeds subject to variations in assumed coefficients from new values for seal and wearing ring clearances, bearing clearances, and impeller destabilizing forces. Unless specifically accepted by the construction manager, the range in variation of component characteristics (either clearances or forces) is 2 times as-new values. Forced response is also calculated at new and 2 times as-new values (or approved deviation) using rotor unbalance (10 percent of weight at each impeller position) and hydraulic unbalance at not less than five operating conditions within the envelope of continuous-duty operating conditions specified in (a). Response to unbalance is assessed by the design professional relative to acceptable bearing loads and deflections of the rotating group.

f) The mathematical calculation tools to be employed for the analyses and the procedures to be used are as follows:

(1) Build the mathematical model of the rotating group on a dedicated rotordynamics code employing finite-element beam theory. Do not use general-purpose finite-element, transfer matrix, or lumped-parameter program for this purpose. Construct the model specifically to contain axisymmetric models of the rotor and, with column-type pumps only, the casing. Use this model to determine the damped natural frequencies and, if required, the forced response of the rotating group.

(2) Use a general-purpose finite-element code such as NASTRAN or ANSYS to construct three-dimensional models of the casing and housing structures supporting the rotating group. Use this model to determine the natural frequencies of the support structures and casing as well as the pump-bearing frames. Include representative sections of piping and structural supports such as piers and baseplates in the model.

(3) Adjust the rotating group axisymmetric model, preferably by changing component materials or sizes, or by changing component type, until the output frequencies or static deflections agree with the models constructed under (2).

(4) Use the three-dimensional models constructed under (2) to determine if the foundation of the pumping unit is rigid or flexible as per Figures 9.6.8.3.1a, 9.6.8.3.1b, and 9.6.8.3.1c in ANSI/HI 9.6.8-2014.

2) Include in the Final Report graphic presentations, preferably in three dimensions, of frame and shaft distortion and rotor group performance at any identified critical speeds within the pump's operating range.

b. Torsional dynamic analysis:

1) The methodology used for the torsional rotordynamic analysis of the rotating group and evaluation of shaft combined stresses is based on a Level 2/3 analysis in ANSI/HI 9.6.8 and includes the following features:

a) The procedure considers speeds required to operate the equipment within the envelope of continuous-duty operating conditions specified in paragraph 1.04C.4.aTorsional rotordynamics and combined shaft stress.

b) The mathematical model of the rotating group is built on a dedicated rotordynamics code employing finite-element beam theory or a general-purpose finite-element program. Do not use a transfer matrix or lumped-parameter code for this purpose. The computer program used for the torsional analysis must be field calibrated at not less than five similar installations.

c) Verify the computer analysis results by hand calculations for the fundamental frequency and mode shape.

d) Primary excitation orders to be considered in the analysis are 1- and 2-times running speed, vane-passing frequencies for the pump impeller/cutwater-diffuser vane combinations, line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating engine drivers (up to, and including, 6 times operating speed), and harmonics as defined in (f) if variable-frequency drives (VFDs) are specified.

e) Produce a Campbell-type interference diagram showing the relationship between operating range, natural frequencies, and primary excitation orders, with any critical speeds clearly identified.

f) If critical speeds are predicted to occur in the critical avoidance zone specified in paragraph 1.04C.4.aTorsional rotordynamics and combined shaft stress, perform a damped, steady-state forced-response analysis to demonstrate satisfactory fatigue life as defined further in that paragraph, as applicable. Forcing function magnitudes used for the analysis shall be not less than 1 percent of the maximum transmitted torque at the speed of intersection. Justification of the source and magnitude of any damping incorporated in the analysis is required. Include in the analysis evaluation of control pulse frequencies induced by VFDs or engine power-stroke frequencies, if provided as part of the specified system. Include in the analysis report a statement produced by the VFD manufacturer detailing control-pulse frequencies generated by the equipment between 1- and 24-times motor running speed. Consider any torque harmonic greater than 1 percent of steady torque a primary excitation order.

2) Physical adjustments to obtain the required characteristics should preferably be implemented through changes in component dimensions, and alternatively through providing torsionally-resilient dampening devices such as fluid-damped couplings or metallic couplings such as manufactured by Bibby and Holset. Do not use couplings or dampeners using rubber or similar elastic materials.

3) If synchronous drives are specified in the mass-elastic design, include in the analysis a time-integration study showing transient peak stresses resulting from startup, shutdown, and motor control transients. Provide tomographic diagrams, colorimetrically displaying stresses at positions in the rotating group shafting, including roots at changes in section and keyways or other stress concentrating locations, with the analysis report. Indicate in the diagrams the operating speeds identified that produce the peak stresses, specific for speeds inducing identified peak stresses at keyways, changes in section, and at connections to other components. Combine the reported stresses incorporating identified loads from torsional, lateral, and hydraulic sources.

C. Cans for Column Pumps:

1. General:

a. This paragraph applies where the detailed specification requires a column-type pump to be installed in a can-type intake.

2. Requirements:
    a. Where the detailed specification requires that a column-type pump be installed in a can, the contractor shall require the pump manufacturer to design and provide the can. Include in the design an arrangement that results in no deceleration down the suction well and into the cone. These provisions, however, are not to be construed as relieving the contractor of responsibility for this portion of the work. Design the cans in accordance with the requirements of ANSI/HI 9.8, and provide design documentation as a part of the information to be submitted under paragraph 1.08.
3. Model testing:
    a. The contractor shall require the pump manufacturer to verify the design of cans for column pumps specified in detailed sections with "custom-engineered" in the section title by physical model tests conducted in accordance with ANSI/HI 9.8.
    b. The acceptance criteria for design confirmation and final report of the model study are as set forth in ANSI/HI 9.8.
    c. The physical model shall include the pump, can, upstream inlet piping, and any valves or piping appurtenances within the 10 pipe diameters upstream reach preceding the can.
    d. The physical modeling effort will be the product of a commercial hydraulics laboratory specializing in physical model studies of this type. Hydraulics laboratories associated with colleges or universities and pump manufacturer's hydraulics laboratories are specifically prohibited from providing this service. All development work required to the conduct of the study shall be under the direct supervision of an engineer licensed to practice in at least one of the states composing the United States, hereinafter called "the design professional" for the purposes of this paragraph. The design professional shall have not less than 10 years' experience in hydraulic modeling of pump intake designs of at least the magnitude required by these specifications, using physical modeling techniques. Computational fluid dynamics (CFD) modeling techniques are not an acceptable substitute for the requirements of this paragraph. The Final Report, describing the work performed and the results and recommendations arising out of the study, shall bear the original seal and signature of the design professional.

1.06 QUALITY ASSURANCE: ALL PUMPS

A. Quality Certification:
    1. All manufacturers and manufacturing sites proposed by the contractor for supply of equipment furnished under this section and sections referencing this section shall hold current certification under ISO 9001. Application for certification under ISO 9001 is not deemed as an acceptable substitute for current certification. Provide documentation of the manufacturer's ISO 9001 certification and the manufacturer's written quality assurance/quality control (QA/QC) program.

B. Unit Responsibility:
   1. The contractor shall assign unit responsibility to the pump manufacturer in conformance with the requirements of Section 43 05 11.

C. Performance Confirmation:
   1. Hydrostatic tests:
      a. Subject all pressure-sustaining parts to factory hydrostatic tests. Unless otherwise specified, conform hydrostatic tests to the requirements of ANSI/HI 11.6 for submersible pumps and ANSI/HI 14.6 for dry pit pumps. Unless otherwise indicated in the detailed specifications, hold castings at the test pressure for the duration indicated in ANSI/HI 11.6 and 14.6. For process pumps designed in accordance with ANSI/API 610, hydrostatic testing must comply with the requirements of paragraph 8.3.2 of ANSI/ ANSI/API 610. Test results shall be certified correct by the chief engineer or individual in responsible charge of the manufacturing facility.
   2. Performance guarantee:
      a. Unless specified otherwise in the detailed specification, pump performance (flow and head, efficiency, and NPSH3) shall be guaranteed by the pump manufacturer to the criteria specified under this paragraph.
      b. Equipment performance documentation, including test data, where tests are specified, shall include sufficient test points (not less than eight) to document hydraulic performance along the complete head/capacity curve from shutoff to maximum capacity, and covers full-speed operating points specified in the detailed specification section referencing this section. Tests conducted at specified operating conditions shall be with the inlet throttled to produce the NPSHA indicated for that specific condition in the detailed specification. Perform NPSH3 tests for not less than four full-speed operating conditions, but not less than specified operating conditions and at the best efficiency point (BEPQ).
      c. Test procedures shall be as set forth in ANSI/HI 14.6, and as specifically detailed in these specifications. However, any increase in flow or head permitted under specified acceptance grade[s] cannot result in overload (nameplate basis, S. F. = 1.0) of the specified motor power rating at any location on the pump's head/capacity curve. Conduct performance tests at the specified maximum speed. Affinity relationship-predicted test results will not be accepted. For column-type pumps, include in the performance documentation curves showing both bowl efficiency and overall efficiency (including inlet, bowl, column, and discharge head losses) at maximum operating speed for the application.
      d. The acceptance criteria for head and capacity test results shall be based upon the rated condition specified in the detailed specification and as required in ANSI/HI 11.6 and 14.6 for acceptance Grade 1U, with the above-stated limitation with respect to motor power overload.
      e. Where there are none stipulated, the acceptance criteria for head and capacity test results for the other specified duty conditions in the detailed specification shall be as required in ANSI/HI 11.6 and 14.6 for acceptance grade 3B, with the above-stated limitation with respect to motor power overload.

f. The acceptance criteria for NPSH3 at any specified operating condition shall be the values proposed by the contractor in the curves submitted under paragraph 1.08, and duly accepted by the construction manager, with a tolerance of plus 0, minus unlimited, with the exception that S, as calculated for the specific pump, does not exceed the limitation established under paragraph 1.04B. If the NPSH3 data result in an increase in S, the manufacturer shall confirm that the stable operating region for the pump corresponds to the POR as defined in ANSI/HI 9.6.3, and that the operating conditions specified to be within the POR are within the stable operating region for the pump. In addition, the manufacturer shall identify the onset of suction recirculation and confirm that the onset of suction recirculation is outside of the specified operating range.

g. Include in the guarantee a statement to the effect that the pump will operate within the operating regions specified in the detailed specification. The guarantee shall be in writing and signed by the chief engineer or individual in responsible charge of the test facility. Under no circumstances should deviations from specified operating conditions result in overload of the driver furnished with the equipment, nor should such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

3. Non-witnessed tests:

a. Unless specified otherwise, performance-test pumps in accordance with ANSI/HI 14.6, with the above restrictions on motor power overload. Include in the factory tests test data for each full-speed performance requirement and any other points stipulated for this test procedure in the detailed specification. Conduct these tests with the pump inlet throttled to provide the specified NPSHA. For large-column pumps, model performance testing with reduced NPSHA, pursuant to paragraph 1.07B.4, may be used. If specified in the detailed specification, include shaft vibration and case noise in the test data at the full-speed operating conditions.

b. Duplicate the test setup in the manufacturer's test facility as closely as possible to the inlet conditions in the proposed installation, using temporary baffles and other means, within the limitations of the test facility. Where centrifugal pumps are furnished with inlet elbows, inlet adapters or inlet reducers as a part of the manufacturer's scope of supply, test the pumps with the elbow, adapter, or reducer fitted to the pump and apply specified performance criteria to the complete pump assembly, including losses through any elbow, adapter, or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, test the pumps with these components fitted to the pumps. Apply the specified performance requirements to the complete pumping assembly including any inlet nozzles, and discharge elbows or adapters. Include in the certified test data separate readings for inlet and discharge head for each data point.

c. Take not less than eight test points, including not less than three within plus or minus 8 percent (in terms of rated flow) of the rated condition (Condition Point A) and not less than two test points within plus or minus 4 percent of the pump's BEP at the test speed. In addition, one test point is sufficient to define head and power requirements at shutoff head.

d. Perform NPSH3 tests in accordance with ANSI/HI 14.6, paragraph 14.6.5.8.2.1, Type 1 Test except that not less than four tests should be performed at the test motor speed to completely cover the range of operating conditions specified in the detailed specification. One of the test points shall be at the BEP flow to confirm the test pump's S. The translation of test results to specified operating conditions shall be in accordance with ANSI/HI 14.6, paragraph 14.6.6.1.1 so long as the exponent used can be supported by certified test data performed on a pump of the same type, size, speed, and specific speed as that of the proposed pump. Include NPSH3 tests at both the proposed and test speeds in test data justifying the exponent, test points at BEP, and at least three other points on the test pump head/capacity curve at least 15 percentage points removed from the BEP. Use the results of the NPSH3 tests to confirm the NPSH margins for each specified operating condition as specified in paragraph 1.04F. Perform NPSH3 tests for column type (axial, mixed-flow, and vertical-turbine) pumps using the open sump/water level or closed tank/tank pressure methods described in ANSI/HI 14.6, Table 14.6.5.8.2.1. Perform NPSH3 tests for submersible wastewater pumps using the method described in Figure 11.6.8 in ANSI/HI 11.6. Extend all NPSH3 tests from 50 percent to 140 percent of best efficiency flow at full speed, or to not less than 10 percent (in terms of flow) past the flow at Operating Condition B, whichever is greater. For a given pump, if the manufacturer can provide documentation that the upper flow limit of the AOR on the right side of the pump curve is less than 140 percent of best efficiency flow, the AOR may be used as the limit for the NPSH3 test. Cause for rejection is failure to achieve specified performance or performance proposed in accepted submittal documents (capacity and head, efficiency, or NPSH3), whichever is more restrictive. Acceptance tolerances are as set forth in paragraph 1.06C.2 Performance Confirmation; Performance guarantee.

e. All test procedures shall be in strict conformance with the referenced standards. However, prediction of performance of a trimmed impeller from test data of the larger impeller will not be permitted. If trimming is required, re-test the pump. Do not allow deviations from specified operating conditions, though allowed by the referenced standards, to result in overload of the driver furnished with the equipment, nor allow such deviations to result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

f. The contractor shall furnish the construction manager with not less than 2 weeks' advance written notice of the date and place of the non-witnessed tests.

g. All test results, including test logs and generated curves, shall be certified correct by the chief engineer or individual in responsible charge of the manufacturer's test facility, and shall be submitted in accordance with paragraph 1.08.

1.07 QUALITY ASSURANCE: ADDITIONAL REQUIREMENTS

A. Scope:

1. In addition to the requirements under paragraph 1.06 applicable to pumps, the following are required for the subset of larger and custom-engineered pumps defined in paragraph 1.01A Scope. Contractor is advised that the results of NPSH3 will be used by the construction manager to determine if the tested pumps conform to the POR requirements set forth in paragraph 1.04. Failure to meet these requirements will likely require remanufacture of the pumps or rework of one or more of the pump components to achieve the required and necessary pump stability characteristics. All costs associated with such remanufacture or rework and retesting shall be borne by the contractor.

2. The performance curves submitted under paragraph 1.08, once accepted by the construction manager, shall become a warranty on the part of the contractor to provide equipment that will provide performance characteristics that accurately duplicate the characteristics presented in the submitted and accepted curves. The factory test results shall confirm performance within the tolerances set forth in ANSI/HI 14.6.3 and paragraph 1.06.C.2, NPSH3, as determined by certified factory test results, shall not cause the pump's S to exceed the limit specified in this section or the detailed specification. The manufacturer may propose a pump with a higher S, provided that documentation showing that the onset of suction recirculation is to the left of the pumps specified operating region. Submit documentation of the procedures used to determine the onset of suction recirculation.

B. Performance Testing:

1. Witnessed tests:

   a. Subject all custom-engineered pumps, and other pumps where required by the detailed specification, to a witnessed factory performance test and NPSH3 tests in accordance with the provisions of this portion of the specifications.

   b. The contractor shall furnish the construction manager with not less than 2 weeks' advance written notice of the date and place of the witnessed tests.

2. Performance tests:

   a. Factory performance tests shall comply with the requirements of ANSI/HI 14.6. Include in the factory tests test data for each full-speed performance requirement and any other points stipulated for this test procedure in the detailed specification. Conduct these tests with the pump inlet throttled to provide the specified NPSHA or as otherwise detailed in the accepted test plan. For large-column pumps, model performance testing with reduced NPSHA, pursuant to paragraph 1.07B.4 Performance Testing; Model tests, may be used. Include shaft vibration and case noise at full speed in the test data.

b. Duplicate the test setup in the manufacturer's test facility as closely as possible the inlet conditions in the proposed installation, using temporary baffles and other means. Where centrifugal pumps are furnished with inlet elbows, inlet adapters, or inlet reducers as a part of the manufacturer's scope of supply, test the pumps with the elbow, adapter, or reducer fitted to the pump. Specified performance criteria shall apply to the complete pump assembly, including losses through any elbow, adapter, or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, test the pumps with the inlet nozzles or adapters. The specified performance requirements shall apply to the complete pumping assembly, including any inlet nozzles, discharge elbows, or adapters. NPSHA shall not exceed that specified in the detailed specification during any performance test. Include separate readings for inlet and discharge head for each data point in certified test data.

c. Take not less than eight test points, including not less than four within plus or minus 8 percent (on the basis of rated flow) of the rated condition (Condition Point A) and not less than two test points within plus or minus 4 percent of the pump's BEP at the test speed. In addition, one test point is sufficient to define head and power requirements at shutoff head, and one test point is sufficient to define flow at Condition Point B.

3. NPSH3 tests:
   a. Perform NPSH3 tests to confirm the data used to establish NPSHA margin for each specified operating condition as specified in paragraph 1.04F. Perform NPSH3 tests for submersible wastewater pumps using the method described in Figure 11.6.8 in ANSI/HI 11.6. Extend all NPSH3 tests from 30 percent to 140 percent of best efficiency flow at full speed, or to the upper limit of the AOR as defined by the manufacturer, whichever is less. Cause for rejection is failure to achieve guaranteed performance or performance proposed in accepted submittal documents, whichever is the more restrictive (capacity and head, efficiency or NPSH3). Tolerances and restrictions are as set forth in paragraph 1.06C.3 Performance Confirmation; Non-witnessed tests, above, for non-witnessed tests.
4. Model tests:
   a. Where allowed in the detailed specification or upon specific application with adequate justification by the manufacturer, confirmation of performance of large pumps may be demonstrated by testing the prototype at reduced speed or by testing a model of the prototype pump. Perform NPSH3 tests to confirm the data used to establish NPSHA margin for each specified operating condition as specified in paragraph 1.04F. Cause for rejection is failure to achieve guaranteed performance (capacity and head, efficiency or NPSH3). Perform physical model testing at qualified, commercial facilities, with at least 10 years of continuous-duty operation. Conduct all tests in accordance with ANSI/HI 1.6 or 2.6. with the following restrictions:
      1) If the prototype is tested at reduced speed, the ratio of test speed to prototype speed shall be not less than 0.66:1.
      2) Model test ratios shall be not less than 0.33:1, model to prototype.
      3) Impellers for model tests shall be a minimum of 12 inches in diameter.

4) Subject impellers for prototype pumps to a model-to-prototype profile comparison using templates ratioed from the impeller used for the completed and accepted model test. Compare impeller profiles for the x, y, and z planes. If model testing is proposed for any or of the specified tests, the contractor shall include the proposed methodology for profile confirmation as a part of the submittal material required under paragraph 1.08. Perform impeller profile comparison with a representative of the construction manager present. All costs associated with travel and subsistence of the construction manager's representative shall be borne by the contractor.

5) Acceptance criteria, based upon projected prototype performance from model test results using ANSI/HI-approved affinity relationships, are as set forth above under paragraph 1.06C.3 Performance Confirmation; Non-witnessed tests.

6) Apply the restrictions set forth above for witnessed tests.

b. The contractor shall furnish the construction manager with not less than 2 weeks' advance written notice of the date and place of the model tests.

5. Test certification and reporting:

a. An officer of the pump manufacturer or chief engineer of the test facility shall certify correct all test results, including test logs and generated curves. The contractor shall submit test results as an informational submittal.

C. Confirmation of passage geometry:

1. For solids-handling pumps, subject the design waterway passages and mating passages between rotating and stationary portions of such passages to confirmation that no mismatch of exiting and entering angles or angular discontinuities exist in pumps furnished under specification sections containing the words "custom-engineered" in the title, and that are not proven designs in accordance with paragraph 1.04B. The confirmation process shall employ CFD modeling techniques in which mesh generation is optimized and mesh size is reduced in the regions of flow attachment, detachment, and separation regions of the impeller and cutwater to detect angular mismatches of 0.25 degree or greater.

2. Use a number of different convergence criteria to assess whether a solution is converged. These criteria may include the residuals given by the software; global imbalances in momentum, energy, etc.; whether key global quantities have reached an equilibrium value; and whether information from various solution monitoring points have stabilized. Note that these monitoring points should be in areas where the flow could be much weaker, and not where the flow could be converged easily. Use high-convergence criteria, and repeat runs with different monitoring points to ensure proper convergence.

3. Provide modeling software that is professionally customized and optimized for the determination of pump fluid dynamics, especially flow attachment, detachment, and separation. Verify the mathematical model and software accuracy by experimental data from test cases including similar dynamics. The individual conducting the modeling effort shall be a CFD specialist with graduate-level education in the subject and over 5 years of relevant experience. Submit the model graphic outputs, signed and notarized by the pump manufacturer's officer in charge of engineering, as a part of the documentation required under paragraph 1.08.

1.08 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. In addition to the material listed in the detailed specification, provide the following submittals:
      a. Documentation of successful pump designs or proposed alternatives as specified under paragraph 1.04B.1 Pump Selection. If included as part of the design, include in the documentation applications where pump cans of a similar size have been provided as part of the design.
      b. A Certificate of Unit Responsibility attesting that the contractor has assigned unit responsibility in accordance with the requirements of this section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
      c. A copy of this specification section and the specification sections listed for submittal in the detailed specification sections. Ensure that the specification copies are complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore, requested by the contractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the contractor with the specifications. Accompany the submittal with a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal is sufficient cause for rejection of the entire submittal with no further consideration.
      d. A copy of the contract document control diagrams and process and instrumentation diagrams (P&IDs) relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings as “no changes required.” Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review.
      e. Documentation of certification in accordance with ISO 9001 as specified under paragraph 1.06A.

f. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the vertical axis plotted against capacity on the horizontal axis, along with the manufacturer's warranty to meet the requirements specified in paragraph 1.07 Scope. Provide curves for variable-speed pumps to demonstrate operation at speeds required to achieve the specified reduced-speed operating conditions. All curves shall clearly display the specified operating conditions and conformance with POR and AOR limits in the individual specification sections. Provide variable-speed plots showing specified operating conditions and POR limits. Plot curves at increments of not more than 5 percent speed or 50 rpm increments, whichever is less, from full speed to the lowest speed required to meet specified operating conditions. Curves for column-type pumps shall show bowl efficiency and allowances for inlet, column, and discharge head losses separately.

g. NPSH margin calculations performed for each specified operating condition in accordance with paragraph 1.04 as applicable and including the information required under paragraph 1.04F.

h. Motor submittal information as specified in Section 43 05 21. In addition, include in this information certified calculations for motor rotor and frame reed frequencies, as specified under paragraph 1.04G.

i. Complete description and sketch of proposed test setup for factory test if a factory test has been required under the detailed specification section or as required by the provisions of this section. Include in submittal material sample calculations and proposed test log format. If the contractor proposes a model test for a part or all of the specified performance tests, include in the submittal information the proposed model details and a complete description of the proposed method for comparing the model impeller profiles with the impeller profiles for the prototype pumps.

j. Drawings showing general dimensions and confirming the size of pumps, motors, drives, and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.

k. Variable-speed drive information as required under Section 26 29 23 if the equipment specified includes variable-speed capability.

l. Driver unit support calculations and data if the driver is separately supported and if the analysis under the requirements of paragraph 1.05B have been required by the terms of these specifications.

m. Shaft deflection calculations for volute-type pumps: provide calculations to demonstrate compliance with paragraph 1.04E, per the methodology set forth as required by paragraph 1.05B.

n. Detail drawings of the pump and driver unit foundation demonstrating conformance to this section and Section 43 05 13. Include in the submittal drawings depicting type, size, number, projection, and arrangement of anchor bolts; dimensional drawings of the sole and baseplates; and dimensional drawings for the concrete supports for both the pump and motor, if applicable. Drawings shall also depict other pertinent information, including location of equipment pads and reinforcement; equipment drains; expansion joint locations; elevation of top of grout and grout thickness; elevation of top of baseplate, soleplate, or mounting block; size and location of electrical conduits; and any other equipment-mounting features embedded in equipment pads.

o. Limiting nozzle loading criteria, if different from that established by ANSI/HI 9.6.2.

p. The qualifications of the personnel proposed by the contractor to perform field alignment procedures in accordance with the requirements of paragraph 3.04.

3. The following are applicable to all vibration testing of pumps, in accordance with the requirements of paragraph 3.06 Field Vibration Tests and, paragraph 3.07 Torsional Vibration Testing, where required:

   a. The qualifications of the independent testing laboratory and individual personnel proposed by the contractor to perform field vibration testing, analysis, and reporting.

   b. Proposed vibration testing plan. including accelerometers mounting and presentation formats.

4. The following are applicable for pumps specified to meet ANSI/HI 9.6.8 Analysis Level 2 or 3:

   a. Qualifications of the design professional, and firm name, proposed to perform the mass elastic design analyses specified under paragraph 1.05B, or the manufacturer's qualified design professional conducting Alternate mass elastic design analyses under paragraph 1.04C Critical Speeds and Natural Frequencies, where required by the detailed specification section, if the subject analyses are required by the terms of these specifications.

   b. Descriptive material outlining the methodology and software to be used in the analyses required under paragraph 1.05B and paragraph 1.04 Critical Speeds and Natural Frequencies, as applicable.

   c. "Executive Summary" report of the mass elastic design analyses for pumps as specified in paragraph 1.05B, for custom-engineered pumps, and for Alternate mass elastic design specified under paragraph 1.04 Critical Speeds and Natural Frequencies, where required by the detailed specification section.

   d. The proposed instrumentation setup for the in situ torsional vibration test specified under paragraph 1.05B.

   e. Can design documentation specified under paragraph 1.05C, including bolt patterns for the pump base and soleplate on can.

   f. "Final Report" of the model study specified under paragraph 1.05C.

   g. Model graphic outputs specified in paragraph1.07C.

B. Informational Submittals

1. Procedures: Section 01 33 00:

   a. Performance guarantee as specified in paragraph 1.06C.

   b. Equipment anchor calculations specified in paragraph 1.04E.

   c. O&M information specified in Section 01 78 23.

   d. Motor information submittals as specified in Section 43 05 21.

   e. Bearing L-10 life calculations.

   f. Critical speed calculations demonstrating compliance with paragraph 1.05B if a lateral rotordynamic analysis is required. Otherwise, provide critical speed calculations demonstrating compliance with paragraph 1.04C.

   g. Nozzle loading information required under paragraph 3.01.

h. Motor balance logs, certified and notarized as specified in paragraph 1.04G.
i. Certified balance logs and worksheets, as specified in paragraph 2.05.
j. Installation certification Section 43 05 11-Form A as specified in paragraph 3.01.
k. Training certification Section 43 05 11-Form B as specified in paragraph 3.08.
l. If factory tests are specified in the detail specification section, certification of satisfactory testing of each unit as specified. Include in the certified material copies of test logs and resulting performance curves.
m. Documentation of field alignment data in accordance with Section 43 05 14.
n. Field vibration test reports in accordance with paragraph 3.06.

2. The following are applicable for pumps specified to meet ANSI/HI 9.6.8 Analysis Level 2 or 3:

a. Results of model tests for pump cans if model tests are required by the provisions for paragraph 1.05C.
b. "Final Report" of mass elastic systems analyses for pumps as specified in paragraph 1.05B, for custom-engineered pumps, and for Alternate mass elastic design specified under paragraph 1.04 Critical Speeds and Natural Frequencies, where required by the detailed specification section.
c. Results of motor rotor, frame, and assembly bump tests, certified as specified under paragraph 1.04G Electric Motors, along with the design professional's "Supplemental Report" as specified under paragraph 1.05B.
d. Pump can installation acceptance certification, as specified in paragraph 3.03, if applicable.
e. Results of field vibration tests as specified under paragraph 3.06.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Where this section and sections referencing this section are silent with respect to materials of construction on any component, material selection shall follow the requirements of Table H.1, ANSI/API 610, Materials Class I-1, with the exception that shafts for vertical column-type pumps be 12 percent chromium stainless steel. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Pumps:

1. Finish for surfaces in contact with pumped fluid:
   a. Conform all pump components in contact with the pumped fluid to the following requirements.
   b. Indicate surfaces to be machine-finished on the shop drawings by symbols that conform to ANSI B46.1, Surface Texture, Surface Roughness, Waviness, and Lay. Machine surfaces shall be finished to at least the following tolerances:
   c. Nominal roughness:

Surface	Grade, Ref: ANSI B46.1 (SI units microns) (Ra: micro inches)
General machine work	3.2 or better (125 Ra)
Flange faces	3.2 or better (125 Ra)
Journal surfaces at sleeve bearings	0.4 or better (16 Ra)
Hydraulic surfaces	
Impeller	4.5 or better (177 Ra)
Impeller bowl and diffuser	6.3 or better (250 Ra)
All other wetted surfaces	6.3 or better (250 Ra)

d. Flaws such as scratches, ridges, holes, peaks, cracks, or checks that will make the part unsuitable will be cause for rejection. Machine-finished surfaces shall be thoroughly cleaned and coated with a protective layer of rust preventive. Oil and wrap small pieces, unassembled pipe, or finished bolts with moisture-resistant paper.

2. Materials:
   a. Unless otherwise specified, wetted cast-iron parts for pumps for solids-bearing liquid services shall have 2 to 3 percent nickel added to the cast iron.
   b. Provide stainless-steel impellers for the first stage of custom-engineered pumps, pumps intended for pumping screened or unscreened wastewater, and elsewhere when specified. Stainless-steel impellers shall be ASTM A743, Grade CA6NM. Where cast-nickel aluminum bronze impellers are specified, the materials shall conform to ASTM B148, Alloy C95500.
   c. Materials for shaft sleeves for packed boxes, fretting seals, and interstage seals shall conform to ANSI/API 610, Annex H 12 percent chromium-hardened or hard-faced 316 austenitic stainless steel. Materials for seal glands for packed boxes and shaft sleeves shall be AISI 316 stainless steel. Fastener parts of all types in wetted areas shall conform to ANSI/API 610, Materials Class S-5 requirements. Regardless of the seal construction, adequately size seal chambers to accommodate specified mechanical seals.

C. Flywheels: [Not Used]:

2.02 GENERAL QUALITY

A. The details of manufacture and assembly of equipment furnished under this section and referencing sections shall follow the requirements of ANSI/API 610 with respect to the following features (paragraph references, ANSI/API 610):
   1. Alignment aids (paragraph 6.1.24)
   2. Removal of rotating element (paragraph 6.1.25)
   3. Jackscrews for assistance in alignment on baseplates and equipment supports (paragraph 9.3.8.3.2)
   4. Castings (paragraph 6.12.2)

B. Provide all components or subassemblies weighing 50 pounds or more with at least one lifting eye or a provision for threading in a lifting eye. Provide components 250 pounds or greater with lifting eyes or provisions for at least two lifting eyes. Provide components 1,000 pounds or greater with at least three lifting eyes or provisions for inserting lifting eyes.

2.03 BASEPLATES AND SOLEPLATES

A. Unless otherwise noted in the detailed specification, the pump manufacturer shall furnish pumps with baseplates or soleplates conforming to the requirements of Section 43 05 13. Design baseplates and soleplates to be installed in the housekeeping curb shown and machine flat and co-planar to within 0.002 inch per foot in all directions on the face mating with the pump and motor or driver support. Soleplates shall have the words “THIS SIDE DOWN” permanently affixed to the underside using a welding rod material or stamped prior to milling. Alternative marking methods, using heavy scribing or machining, are acceptable provided that they may be observed following blasting in preparation for coating.

2.04 WEARING RINGS

A. Where specified, fit pumps with both stationary and rotating wearing rings. Except for the difference in hardness between stationary and rotating rings, wearing rings shall be stainless steel and conform to the requirements of ANSI/API 610, paragraph 6.7 and material class S-8 (Table H.1, Annex H). The maximum wearing ring clearances shall not exceed 150 percent of the values stated in Table 6, ANSI/API 610. The minimum wearing ring hardness on the rotating ring is 350 Brinell Hardness Number (BHN), with the stationary ring not less than 100 hardness points greater.

2.05 BALANCE

A. The balancing for pumps with suction nozzle sizes 6 inches in diameter and greater and associated components shall conform to the requirements set forth in ANSI/API 610, paragraph 6.9.4.1 (equivalent to ISO 1940 or ANSI 2.19 Grade 2.5), unless other portions of this project manual impose more restrictive requirements. It is the intent that the components be balanced as an assembly (“rotor”) in accordance with ANSI/API 610 definitions. For extended-shaft pumps, balance impeller(s) and shaft up to the first coupling with the line-shaft.

B. For separately balanced components, perform a residual unbalance inspection after rotor assembly per ANSI/API 610 requirements, as described in Annex J of that document. Provide copies of worksheets and demonstrate that tolerances are in compliance (i.e., rotor has passed) in addition to other reporting requirements of this paragraph.

C. Furnish all balance logs, certified correct and signed by the chief engineer or individual in responsible charge of the manufacturing facility, in accordance with paragraph 1.08.

2.06 DRIVE UNIT SUPPORTS FOR SEPARATELY SUPPORTED MACHINES AND INTERMEDIATE SHAFT SUPPORTS

A. Supports for separately mounted vertical pump drivers and intermediate shaft bearings shall be composite structures of fabricated steel, ASTM A36. Unless otherwise specified, design the supports to span an opening in the floor sufficient to allow removal for the complete pump. Provide rolled steel beams to stiffen the support and mount a fabricated steel driver unit support pedestal on the support plate. The support pedestal top plate and portions of the support plate assembly intended to join with surfaces in the installation structure shall be milled flat and parallel to 0.002 inch per foot. Provide pedestals with access provisions to adjust or assemble/disassemble couplings. Select a support that is designed to be supported on a soleplate or soleplates embedded in a housekeeping pad at the edges of the floor opening or as indicated. Other details for the driver unit support shall be as indicated.

2.07 FLYWHEEL ASSEMBLIES [NOT USED]

2.08 CANS FOR COLUMN-TYPE PUMPS

A. Unless specified otherwise, fabricate cans for column-type pumps from ASTM A36 steel with internal baffles fillet-welded to the interior surface of the can. Provide seal welds at welded joints and ensure that welds are ground smooth. Prepare and coat all internal surfaces after welding with fusion-bonded epoxy conforming to the requirements of AWWA C213 using NSF/ANSI 61-compliant materials (3M Scotchkote 134, or approved equal). The minimum coating thickness is 12 mils. The external epoxy coating shall be in accordance with Section 09 90 00 requirements.

B. Where the detailed specification requires a can suitable for service with an upstream hydraulic gradient in excess of the elevation required for the pump discharge head, gasket or fit the flanged connection to the pump discharge head with a double O-ring seal designed to withstand not less than twice the pressure specified in the detailed specification

2.09 MACHINING

A. Unless otherwise specified, provide machined surfaces with a 125 Ra (micro-inch) finish without any grooves, surface imperfections, or machining marks. Mating surfaces shall be coplanar within a maximum of 0.002 inch. Bearing housings and seals shall have collinear centerlines within less than 0.001-inch total difference. Provide shafts with a 63 Ra (1.6-micron) finish at fit areas (coupling, sleeves, impeller) and 125 Ra (3.2-micron) finish at the clear spans.

PART 3 EXECUTION

3.01 GENERAL

A. With the exception of submersible pumps and the inlet connection for column-type pumps installed in open forebays or wetwells, connect pump inlet and discharge nozzles to field piping using equipment connection fittings conforming to the requirements of Section 40 05 06.16. Select restraining rods on equipment connection fittings that is designed specifically to restrain the unbalanced hydraulic thrust developed by the pump when operating at full speed against a closed valve. Torque all restraining rod nuts to ensure that any moment or shear transmitted to the pump nozzles is within the values permitted under ANSI/HI 9.6.2, or that permitted by the equipment manufacturer, whichever is greatest. Where ANSI/HI 9.6.2 is silent with respect to any particular aspect of allowable nozzle loads, the contractor shall follow the written requirements provided by the equipment manufacturer. Install all pumps furnished under specification sections containing the words “custom-engineered” in the title under the presence of a factory-authorized installation specialist or specialists. Under no circumstances shall any installation procedure take place without the installation specialists present. Equipment installation procedures shall conform to the requirements of Section 43 05 13. Upon completion of installation work, the contractor shall submit a complete, properly signed certification Form 43 05 11-A as specified in Section 01 99 90.

3.02 SOLEPLATES

A. Level soleplates, if provided pursuant to this section or any section referencing this section, or where required by the equipment manufacturer’s recommendation, in the presence of a factory-authorized installation specialist to a maximum tolerance of 0.002 inch per foot in all directions. Where the equipment manufacturer requires more stringent tolerances, those tolerances prevail.

3.03 PUMP CANS

A. When specified, install pump cans as indicated to the following tolerances:

Horizontal position	±0.125 inch in all directions
Vertical axis	within 0.5 degree from vertical
Level	0.02 inch per foot of diameter at the pump baseplate bolt circle
Elevation	±0.125 inch from planned elevation

B. Where the equipment manufacturer requires more stringent tolerances, those tolerances prevail.

C. Equipment shall not be installed in pump cans until the pump manufacturer’s factory-trained and authorized installation specialist has furnished the construction manager with written and signed certification that the can has been installed satisfactorily and is acceptable for installation of the equipment.

3.04 ALIGNMENT

A. Journeymen millwrights shall perform alignment of equipment furnished under this section and any referencing section. Carpenters, laborers, or any other trades are specifically excluded from performing this work. In locations where such trades are not available, the contractor shall retain the services of a firm specializing in this type of work to perform the setting and alignment work. The contractor shall submit the qualifications of the proposed firm to the construction manager for acceptance prior to performing the work. The construction manager shall personally witness the final alignment procedures for each item of equipment as a condition precedent to beginning any work required under Section 01 45 20. Alignment techniques shall conform to the requirements of Section 43 05 14.

3.05 FIELD TESTING

A. Field testing shall conform to the requirements of Section 01 45 20 and the detailed specification sections.

B. For pumps furnished under specification sections containing the words “custom-engineered” in the title, and where the manufacturer’s qualified design professional has conducted the Alternate mass elastic design analyses specified under paragraph 1.04 Critical Speeds and Natural Frequencies, the testing procedure is a plan developed jointly by the contractor and equipment manufacturer to demonstrate performance of each item of equipment at specified operating conditions.

C. Unless otherwise specified in the detailed specifications, field-test centrifugal pumps for lateral vibration in accordance with paragraph 3.06B. In addition, “custom-engineered” pumps, and pumps subjected to Alternate mass elastic design analyses under paragraph 1.04 Critical Speeds and Natural Frequencies, shall undergo field torsional vibration testing (paragraph 3.07A).

3.06 FIELD VIBRATION TESTS

A. Qualifications:
   1. The contractor shall retain the services of an independent testing laboratory to conduct the testing work specified under this paragraph. The work shall be directed by a professional mechanical engineer, registered to practice in any one of the 50 states composing the United States.
      a. The engineer (hereinafter termed “professional vibration analysis specialist”) shall be a graduate of a college holding Accreditation Board for Engineering and Technology Inc. (ABET) accreditation in mechanical engineering and has been engaged in the practice of providing the type of monitoring services required under this paragraph for rotating machinery for a period of not less than 10 years.
      b. As an alternate qualification, the professional vibration analysis specialist shall have an ISO/ANSI Vibration Analyst Category IV and been engaged in the practice of providing the type of monitoring services required under this paragraph for rotating machinery for a period of not less than 10 years.

2. Submit the professional vibration analyst specialist's qualifications and references, certified and notarized, for review and acceptance by the construction manager not less than 6 weeks prior to the date scheduled for the field vibration test work specified herein. The construction manager shall review the required documentation and references and indicate acceptance or rejection of the proposed analyst's qualifications within 14 days of submission. If the analyst proposed by the contractor is rejected, the contractor shall propose an alternative choice with appropriate documentation.
3. The independent testing laboratory's testing team (comprising the professional vibration analysis specialist and any technicians required to complete the specified tasks) shall be fully equipped to provide continuous pressure, velocity, and displacement values for rotating equipment installed under the requirements of this section. Vibration testing equipment shall include sufficient calibrated pressure and flow monitoring devices to determine pump operating conditions as well as vibration levels.

B. Vibration Tests:
1. Submit vibration testing plan, prepared by the professional vibration analysis specialist, for review and acceptance by the construction manager not less than 3 weeks prior to the date scheduled for the field vibration test work specified herein.
   a. Proposed vibration testing plan, incorporating corresponding pump performance testing, shall be developed to demonstrate absence of natural frequency excitation (resonance) and compliance with specified vibration limits within the pump operating range.
   b. The professional vibration analysis specialist shall consider identified standards and others consistent with practice standards of care in preparing the plan and directing the work.
   c. As part of the plan, professional vibration analysis specialist shall specify and justify selection and mounting of the vibration sensors (fully adhered or magnet-mounted) in accordance with accepted practice and specified requirements. Hand-held probe accelerometers shall not be used.
   d. Plan shall also stipulate the data collection and processing method including frequency response averaging of spectra and waveform points for each discrete measurement.
   e. Include example presentation formats consistent with specifications and accepted practice.
2. Unless otherwise specified in the detailed specification, the RMS vibration velocity shall not exceed the limits established in the appropriate standards indicated in the Table below. The measurement locations shall correspond to the guidelines provided in the specific standards given in the Table below.

Component	Standard
All Pumps	ANSI/HI 9.6.4 or ANSI/HI 11.6
Electric Motors of Any type	ISO 10816-3 Table A.1 or A.2, Zone Boundary A/B
Reciprocating engines	ISO 10816-6 Table A.1, Class 3
Support bearings, flywheels	ISO 20816-1

3. Testing:

a. Perform ramp (sweep) test of pump vibrations (at average or higher head conditions) – minimum 10 minutes (mins) start-up run, slow ramp from minimum to maximum speeds (20 mins). 20 mins at maximum speed, 10 mins at reduced (A operating speed), 10 mins to confirm largest peak; then through coast down.

b. The professional vibration analysis specialist shall collect vibration readings during the sweep test, make notes about peaks and then proceed to testing with steady state operation at the design and other targeted points. Prepare report of Overall Velocity Trends including pump speed and flow.

c. Conduct discrete performance and vibration testing of all design points (4), when performance is stable but not less than 10 minutes each. It is not necessary to conduct vibration testing at shut-off.

d. Conduct similar discrete performance and vibration testing at each discrete peak observed during the sweep test.

4. Reporting:

a. Provide vibration test reports as an information submittal in accordance with paragraph 1.08, and provide the signature of the responsible professional vibration analysis specialist.

b. The vibration spectra shall be of sufficient resolution for legibility of magnitude and frequency data to be properly reviewed by the construction manager. Cascade diagrams are not sufficient for variable-speed drive application unless supported by the required data in a format suitable for more detailed analyses. Provide separate spectra at the maximum and minimum operating speeds and any potential resonant frequencies.

c. Depict RMS velocity by axis on same plot and zoom in on 10 highest peaks for each separate axis. Report should clearly address multiples of operating speed and twice vane pass at operating speed, typically associated with pump phenomena.

d. Interpret data, identify anomalies and resonant frequencies (if any), provide discussion of probable sources/causes in test report. Provide interpretation as to why there may be peaks beyond typical phenomena.

e. If deemed necessary by the professional vibration analysis specialist, to determine the potential problem and risk with any identified peaks, further resolve and analyze critical peaks by frequency.

C. Remedial Measures:

a. If required, professional vibration analysis specialist shall provide written recommendations for remedy of problems identified.

b. Contractor shall undertake appropriate remedial action, in conjunction with the pump manufacturer, and provide professional vibration analysis specialist services, and pump manufacturer services throughout the process required to resolve identified problems.

c. Conduct additional testing after modifications or replacements to confirm effectiveness of remedy.

3.07 FIELD TORSIONAL VIBRATION TESTING

A. As required in paragraph 1.05 for custom-engineered pumps, and pumps subjected to Alternate mass elastic design analyses under paragraph 1.04 Critical Speeds and Natural Frequencies, perform field torsional vibration tests.

B. Qualifications:
   1. Work shall be conducted under the direct supervision of the design professional responsible for the mass elastic system design on an installed pumping unit selected by the construction manager.
   2. Submit qualifications of the firm and analyst demonstrating training and competency in the required testing, consistent with the requirements of paragraph 3.06 Field Vibration Tests.

C. Submit testing plan and reporting documentation consistent with the requirements of paragraph 3.06 Field Vibration Tests.

D. Provide remedial measures consistent with the requirements of paragraph 3.06 Field Vibration Tests.

3.08 TRAINING

A. Training shall conform to the requirements of Section 01 79 00 and include separate training sessions for each operator shift maintained by the Owner and a separate session for maintenance personnel.

B. Unless otherwise specified in the referencing section, the training requirement is waived for constant-speed pumping equipment with suction nozzle sizes 6 inches in diameter and smaller and for pumps with connected power requirements 10 hp and less.

C. The training session for maintenance personnel shall include a comprehensive presentation, employing cut-away models or comparable graphics, and documentation on the step-by-step disassembly and subsequent reassembly of a pumping unit.

D. Upon completion of training requirements, the contractor shall submit certified Form 43 05 11-B as specified in Section 01 99 90.

END OF SECTION

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SECTION 43 23 61

CONSTANT SPEED VERTICAL TURBINE PUMPS, OPEN LINESHAFT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Constant speed single or multi-stage vertical turbine diffuser pumps for pumping fluids that may contain mildly abrasive small diameter solids.
   2. Provide pumps complete with intake bell, discharge column, discharge head and electric motor.
   3. Select equipment furnished under this section that will comply with the requirements of this section and Section 43 23 03.

B. Equipment list:

Item	Equipment Number
Plant Water Pump 1	73-P-00010
Plant Water Pump 2	73-P-00020

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below:
   1. Section 43 05 11: General Requirements for Equipment
   2. Section 43 05 13: Rigid Equipment Mounts
   3. Section 43 05 14: Machine Alignment
   4. Section 43 05 21: Common Motor Requirements for Equipment
   5. Section 43 23 03: General Requirements for Centrifugal and Axial Flow Pumping

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
AISC	American Institute of Steel Construction—Manual of Practice
ANSI/API 610	Standard for Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
ANSI/ASME B46.1	Surface Texture, Surface Roughness, Waviness and Lay
HI Standards	Hydraulic Institute Standards

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment Pad: Concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.
   2. Mounting Pads: Thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. See Section 01 12 16 Work Sequence.

B. Pre-installation meetings

C. Sequencing

D. Scheduling

E. Unit responsibility: Assign unit responsibility, as specified in Section 43 05 11, to the pump manufacturer for the pumps, seal water control unit assemblies, and motors specified in this section. Provide a completed and signed Unit Responsibility Certification Form (Form 43 05 11-C, Section 01 99 90).

1.06 SUBMITTALS

A. Action submittals:
   1. Procedures: Section 01 33 00.
   2. Conform submittals to the requirements of Section 43 23 03. Sections to be marked-up and submitted in accordance with Section 43 23 03 requirements include:
      a. Section 43 05 11: General Requirements for Equipment
      b. Section 43 05 13: Rigid Equipment Mounts
      c. Section 43 05 14: Machine Alignment
      d. Section 43 23 03: General Requirements for Centrifugal and Axial Flow Pumping Equipment
      e. Section 43 05 21: Common Motor Requirements for Equipment

B. Informational submittals:
   1. Procedures: Section 01 33 00.
   2. Conform submittals to the requirements of Section 43 23 03.

C. Closeout submittals:
   1. Procedures: Section 01 78 23.
   2. Conform submittals to the requirements of Section 43 23 03.
   3. Spare parts:
      a. Procedures: Section 01 33 00.

b. For each unit consisting of one or two pumps of like size and service furnished under this section, one set of the following spare parts shall be furnished. Two sets shall be furnished for each unit consisting of more than two pumps of like size and service.

c. Provide the following spare parts:

1) One set bowl bearings

2) One lineshaft bearing assembly

3) One set wear rings

4) One shaft seal, complete

d. Tag and store spare parts in accordance with provisions of Section 43 05 11.

1.07 QUALITY ASSURANCE

A. Certifications:

1. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001.

2. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.

3. Welder Certification

a. ASME Section IX and/or AWS

B. Critical speeds: Critical speeds shall be in accordance with Section 43 23 03-1.04 except when the title of the detailed section includes "Custom Engineered" in which case Section 43 23 03-1.05 applies.

C. Vibration limits: Vibration limits shall be in accordance with Section 43 23 03-3.06 and subject to field testing in accordance with paragraph 3.04 of this section.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

1.09 SPECIAL WARRANTY [NOT USED]

PART 2 PRODUCTS

2.01 OWNER-FURNISHED EQUIPMENT [NOT USED]

2.02 MANUFACTURERS

A. Manufacturers: Candidate manufacturers are listed below. The manufacturer's standard product may require modification to conform to specified requirements:

1. Fairbanks-Morse
2. Floway
3. Flowserve
4. Goulds

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service conditions:

Description	Value
Equipment number	73-P-00010 73-P-00020
Area exposure	Indoors, No Area Classification
Fluid type	Potable Water
Maximum operating pressure	100 psi

B. Operation Conditions:

Operating Condition	
Condition A [a,b]	
• Capacity, gpm	120
• Total head, psi	85
• NPSHA, feet	TBD
Condition B [b,d]	
• Capacity, mgd	From pump H/Q curve
• Total head, psi	60
• NPSHA, feet	TBD
Condition C [c,d]	
• Capacity, mgd	From pump H/Q curve
• Total head, feet	90
• NPSHA, feet	TBD

Notes:

a. *Take Condition A as the rated, continuous-duty operating condition. Guarantee performance at the rated condition in accordance with Section 43 23 03. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Select pumps furnished under this section to achieve Condition A performance, and also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer's published application data for the specific model proposed for this application.*

b. *Condition B head is presented to indicate operating conditions when the pump is operating against minimum anticipated system head, assuming a hypothetical head-capacity curve. Use Condition B for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ and shall not be less than 10 percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Net positive suction head available (NPSHA), as listed for Condition B is calculated on a pumped flow of 130 mgd.*

c. *Condition C is the anticipated continuous duty maximum head condition. Provide pumps furnished under this specification that are capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 43 23 03. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application.*

d. *Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 2.1–2.6 and are exclusive of pump intake, bowl, discharge column, discharge head and lineshaft losses. A curve showing these losses separately shall be provided as a part of the submittal information required under Section 43 23 03. NPSHA in the above tabulation is referenced to project elevation 5211' and is calculated in accordance with ANSI/HI 2.3 for average barometric pressure and maximum temperature conditions. Calculated NPSHA has been reduced by 2 feet as an allowance for uncertainties associated with the pumped fluid and sump conditions, and no reduction in NPSH margin limitations specified in Section 43 23 03 will be permissible because of the inclusion of this allowance. NPSHA at the pump impeller eye can be determined by adjusting the given value in the above tabulation by proposed pump dimensions and the indicated requirements for pump installation details.*

C. Design requirements:

1. Provide equipment provided under this section that conforms to the following:

Item	Value
Pump	73-P-00010 73-P-00020
Maximum efficiency, minimum, percent [a]	
Bowl	TBD
Pump	TBD
Impeller type	TBD
Piping connection size, inches, minimum	
Discharge	TBD
Minimum bell diameter, inches [b]	TBD
Discharge arrangement	Above Grade
Operating speed, rpm, maximum	TBD
Motor (See Section 43 05 21)	
Horsepower	15
Type (See Section 43 05 21)	Project defined TEFC – (Corrosion) Severe Duty, Enclosed
Inverter duty	No
Space heater	Yes
Thermal protection	Yes
Ambient duty rating	+40
Operating speed, rpm, maximum	TBD
Voltage rating	460 volt, 3 Phase
Hazardous rating	None
Reversing motor	No
Multi-speed motor	No
Motor starting type	Full Voltage
Voltage rating	460 volt, 3 Phase

Notes:

a. *The maximum efficiency is the minimum acceptable peak efficiency and is not required to coincide with any specified operating condition in paragraph 1.01 Performance Requirements. Pump efficiency shall be as defined in Section 43 23 03. Ensure that pump efficiency is within 2 percent of bowl efficiency when calculated at the point of peak bowl efficiency on the pump's head/capacity curve.*

b. *Select inlet bells in accordance with the requirements of Section 43 23 03.*

2. The pumps will be installed in an intake structure designed in accordance with ANSI/HI 9.8, assuming a pump bell velocity of 4.0 feet per second when the pump is operating at the flow produced at the head specified in Operating Condition B. Pumps with inlet velocities less than this value at Operating Condition B are acceptable. If the Contractor proposes a pump with an inlet velocity greater than 4.0 feet per second at the head listed for Operating Condition B, a bell extension fitting, or "umbrella" shall be fitted to the pump to achieve this limitation.

2.04 SYSTEM OPERATION

A. The pumps will be installed in a heated and/or ventilated room at an elevation of 5211' feet above sea level. One pump is a standby pump, while the remainder are duty pumps. The pumps will be controlled by the central plant control system.

2.05 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

Component	Material
Impeller, first stage	Cast nickel aluminum bronze, ASTM B148, C95500
Impeller, all other stages	Cast nickel aluminum bronze, ASTM B148, C95500
Bowls	Close-grained cast Iron ASTM A48 CL30 NSF 61 approved epoxy coating System E-5 per coating specification Section 09 90 00 for potable water application
Hydrocones	Type 316L stainless steel

2.06 COMPONENTS

A. Bell:
   1. Must provide a smooth transition from the diameter specified above under the PERFORMANCE/DESIGN CRITERIA - Design Requirements to the suction case. Provide bolted connections between the bell casting and the suction case. At the manufacturer's option, a bell extension fitting or "umbrella" shall be provided to achieve the specified inlet velocity.

B. Suction case:
   1. Design the suction case to provide conservative entrance velocities and evenly distribute the flow to the impeller. Ensure that the inner surface of the case is smooth and free from projections or cavities. House the pump shaft lower bearing in a streamlined casing, and center and hold in place by means of rigid cast vanes. Design the bearing housing and vanes to conduct the flow efficiently into the impeller eye.

C. Pump bowl:
   1. Flange the pump bowl for registered fit. Provide bolted connections between the suction case and the bowl and between the bowl and adjacent stages or the discharge case. Diffuser vanes shall not be a multiple of impeller vanes. Flow passages through the bowl, and ensure that diffuser vanes are polished or porcelain-lined. If required on multi-stage installations, the first-stage bowl may be designed to facilitate a low NPSH impeller arrangement.
   2. If enclosed impellers are specified, provide replaceable wearing rings on the pump bowl at the impeller inlet connection.

D. Impeller:
   1. Construct impellers free from projections, cavities, or abrupt transitions. Polish the impeller surfaces.
   2. Provide impellers of the type as specified in above in the PERFORMANCE/DESIGN CRITERIA - Design Requirements. If of the enclosed type, fit the shroud with wearing rings. Secure impellers to the pump shaft using tapered collets or keyways.

E. Shafts:
   1. Size shafts to prevent excessive elongation, and to transmit the required torque without distortion in both the forward and reverse direction. Provide shafts with a first critical speed not less than 10 percent below and 20 percent above maximum operating speed. The pumping units shall use a two-piece headshaft, solid intermediate lineshafts supplied in maximum 10-foot lengths, and provide a single pump shaft extending from the suction case through a discharge case or upper bowl case containing an upper pump shaft bearing.
   2. Provide an open line shaft that is lubricated by the product fluid.

F. Bearings:
   1. Provide a suction case, bowl, and lower tube bearings that are close tolerance, spiral grooved, sleeve type. Grease lubricate the suction case bearing. Lubricate bowl sleeve bearings by the pumped fluid. Bearing spacing shall not exceed 5 feet.
   2. Provide bearings that are extra length spiral grooved sleeve type, spaced at not more than 5 feet apart. Lubricate the lineshaft bearings by the pumped fluid.

G. Discharge column:
   1. Fabricate discharge columns with interchangeable pipe sections with flanged joints. Ensure that the column interior is free from offsets, burrs, discontinuities, or irregularities. Supply the column in sections not exceeding 5 feet in length. Provide intermediate spider bushings that align and support the lineshaft enclosure. Provide flanged connections at all column, bowl and discharge head connections.

H. Discharge head and drive unit support:
   1. Provide a discharge elbow that is of the above ground type as specified, mitered or formed to provide a smooth transition from the discharge column to the discharge nozzle. Fit the pump discharge nozzle for connection with a grooved-end pipe coupling or flanged as specified. Fit the discharge head with the specified shaft seal, located to afford convenient access for maintenance. Support the elbow with a fabricated steel baseplate reinforced with ribs designed to carry the weight of the complete pump and drive unit without distortion when spanning an opening sufficient to permit withdrawal of the complete pump without removing the bowl or inlet bell. Cast or fabricate the drive unit support of steel, and design to accommodate the equipment specified. Provide brackets, cartridges and drilled ports as required for all monitoring devices specified in Division 40. The support shall be designed in accordance with Section 43 23 03 and for seismic zone in accordance with Section 01 73 24.
   2. Provide the pump head with a soleplate conforming to Section 43 05 13, manufactured expressly for the discharge head provided.

I. Seal:
   1. Provide a mechanical seal conforming to the requirements of Section 43 05 11-2.04 Mechanical Seals. Provide drilled and tapped connections for connection to an external source of lubricating fluid if specified.

J. Couplings:
   1. Provide a four-piece coupling to connect the motor shaft and headshaft between the motor and the tension nut assembly. Select a four-piece coupling that will provide for impeller adjustment, and include a spacer to permit servicing the seal.
   2. Select lineshaft couplings that are a perfect butt-fit. Design with a safety factor of 1-1/2 times the shaft safety factor and shall have a left-hand thread to tighten during pump operation.

K. Corrosion protection:
   1. Protect the interior of the discharge column, discharge head, and all exterior below grade surfaces of the pump with coating system TBD as specified in Section 09 90 00.

L. Drive unit:
   1. Drive the pump by a vertical solid-shaft motor conforming to PERFORMANCE/DESIGN CRITERIA - Design Requirements specified above, Section 43 05 21, and the requirements of Section 43 23 03. Non-reverse ratchet-equipped motors will not be accepted.

M. Equipment mounts:
   1. Mounting plates: Fabricated steel (stress relieved after fabrication) or cast iron per Section 43 05 13 with provisions for bolting each machine and sufficient thickness to permit dowelling.

2.07 CONTROLS

A. Refer to Division 40 specifications for further control information.

2.08 CONTROL PANELS

A. Refer to Divisions 26 and 40 Sections for further information.

2.09 FINISHES

A. Procedures: Section 09 90 00.

B. Prime coat: Shop applied, coating material per NSF 61.

C. Finish coat: Field applied, coating material per NSF 61.

2.10 SOURCE QUALITY CONTROL

A. Factory testing shall be non-witnessed in accordance with Section 43 23 03.

B. Hydrostatic tests:
   1. Factory test all pressure sustaining parts in accordance with Section 43 23 03.

C. Performance tests:
   1. Subject each pump to non-witnessed performance test in accordance with Section 43 23 03 to verify the full range of operating condition

PART 3 EXECUTION

3.01 EQUIPMENT MOUNTING

A. Procedure: Section 43 05 13.

B. Position equipment pad and equipment anchors for final placement of equipment.

C. Use a bolting template to position equipment anchors.

D. Level baseplate.

E. Pour grout bed supporting baseplate.

F. Eliminate grout voids below baseplate as applicable.

G. Tension equipment anchors.

H. Provide completed Form 43 05 13-A, Section 01 99 00, for each equipment installation.

3.02 ALIGNMENT

A. Procedures: Section 43 05 14.

3.03 FIELD QUALITY CONTROL

A. Field testing:
   1. Lateral vibration testing in accordance with Section 43 23 03.

2. Include in the bid all costs for services of Testing Firms and Design Professionals performing these services.

B. Manufacturer services:
   1. On-site inspections and training: Provide a factory-trained manufacturer's representative at the site for the following activities. Specified durations do not include travel time to or from the site.
      a. Installation inspections: Assist, supervise, and inspect the Contractor's activities during installation. Provide 16 inspection hours. Provide a completed Form 43 05 11-A, Section 01 99 90.
      b. Component test phase inspections: Assist, supervise, and inspect the Contractor's activities during the system test phase specified in Section 01 45 20 and this section. Provide 16 inspection hours.
      c. Operational test phase inspections: Assist, supervise, and inspect the Contractor's activities during the operational test phase specified in Section 01 45 20 Provide 16 inspection hours.
      d. Training sessions: Procedures Section 01 79 00. Provide a minimum of 4 hours classroom training for each training session. Conduct one training session to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 43 05 11-B, Section 01 99 90.

3.04 SYSTEMS STARTUP

A. Procedures: Section 01 45 20.

B. Preoperational (factory) testing; See paragraphs 1.07 and 2.11.

C. Component testing: Perform the following tests:
   1. During initial pump installation, verify on one pump that the crane system has the clearance and capacity to lift the wetted-end from the field mounted pump volute to accommodate routine pump maintenance. Provide or modify spreader bar or lifting assemblies as necessary to accomplish this task.
   2. During initial pumping system installation, verify with clean water that the common pump discharge header, and the individual pump suction elbows can be readily drained to the pump room sump for maintenance or pump de-ragging without spilling on to the pump room floor.
   3. Complete lateral vibration testing of all pumps in accordance with Section 43 23 03.

END OF SECTION

SECTION 43 23 62

VARIABLE SPEED VERTICAL TURBINE PUMPS, OPEN LINESHAFT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Variable speed single or multi-stage vertical turbine diffuser pumps for pumping fluids that may contain mildly abrasive small diameter solids.
   2. Provide pumps complete with intake bell, discharge column, discharge head, electric motor, and variable frequency drive (VFD).
   3. Select equipment furnished under this section that will comply with the requirements of this section and Section 43 23 03.

B. Equipment list:

Item	Equipment Number
Backwash Pump 1	70-P-00010
Backwash Pump 2	70-P-00020
Backwash Pump 3	70-P-00030

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below:
   1. Section 43 05 11: General Requirements for Equipment
   2. Section 43 05 13: Rigid Equipment Mounts
   3. Section 43 05 14: Machine Alignment
   4. Section 43 05 21: Common Motor Requirements for Equipment
   5. Section 43 23 03: General Requirements for Centrifugal and Axial Flow Pumping
   6. Section 26 29 23: Variable Frequency Motor Controllers

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
AISC	American Institute of Steel Construction –Manual of Practice
ANSI/API 610	Standard for Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
ANSI/ASME B46.1	Surface Texture, Surface Roughness, Waviness and Lay
HI Standards	Hydraulic Institute Standards

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment pad: Concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.
   2. Mounting pads: Thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. See Section 01 12 16: Work Sequence.

B. Pre-installation meetings

C. Sequencing

D. Scheduling

E. Unit responsibility: Assign unit responsibility, as specified in Section 43 05 11, to the pump manufacturer for the pumps, seal water control unit assemblies, motors and VFDs specified in this section. Provide a completed and signed Unit Responsibility Certification Form (Form 43 05 11-C, Section 01 99 90).

1.06 SUBMITTALS

A. Action submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, and those listed below with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements:
      a. Section 43 05 11: General Requirements for Equipment
      b. Section 43 05 13: Rigid Equipment Mounts
      c. Section 43 05 14: Machine Alignment
      d. Section 43 23 03: General Requirements for Centrifugal and Axial Flow Pumping Equipment
      e. Section 43 05 21: Common Motor Requirements for Equipment
      f. Section 26 29 23: Variable Frequency Motor Controllers

B. Informational submittals:
   1. Procedures: Section 01 33 00
   2. Conform submittals to the requirements of Section 43 23 03.

C. Closeout submittals:
   1. Procedures: Section 01 78 23.
   2. Conform submittals to the requirements of Section 43 23 03.

3. Spare parts:
    a. Procedures: Section 01 33 00.
    b. For each unit consisting of one or two pumps of like size and service furnished under this section, furnish one set of the following spare parts. Furnish two sets for each unit consisting of more than two pumps of like size and service.
    c. Provide the following spare parts:
        1) One suction bell bearing assembly
        2) One set bowl bearings
        3) One lineshaft bearing assembly
        4) One set wear rings
        5) One shaft seal, complete
    d. Tag and store spare parts in accordance with provisions of Section 43 05 11.

1.07 QUALITY ASSURANCE

A. Qualifications
    1. Design Professional for rotordynamic analysis and mass elastic design: Section 43 23 03-1.05.
    2. Independent testing laboratory for vibration testing: Section 43 23 03.

B. Certifications:
    1. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001.
    2. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.
    3. Welder Certification
        a. ASME Section IX and/or AWS

C. Critical speeds: Critical speeds shall be in accordance with Section 43 23 03-1.04 except when the title of the detailed section includes "Custom Engineered" in which case Section 43 23 03-1.05 applies.

D. Vibration limits: Vibration limits shall be in accordance with Section 43 23 03-3.06 and subject to field testing in accordance with paragraph 3.04 of this section.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

1.09 SPECIAL WARRANTY [NOT USED]

PART 2 PRODUCTS

2.01 OWNER-FURNISHED EQUIPMENT [NOT USED]

2.02 MANUFACTURERS

A. Manufacturers: Candidate manufacturers are listed below. The manufacturer's standard product may require modification to conform to specified requirements:

1. Fairbanks-Morse
2. Floway
3. Flowserve
4. Goulds
5. Approved Equal

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service conditions:

Description	Value
Equipment number	70-P-00010 70-P-00020 70-P-00030
Area exposure	Indoor, No Area Classification
Fluid type	Finished Water
Maximum operating pressure	TBD

B. Operating conditions:

Equipment number	70-P-00010 70-P-00020 70-P-00030
Full Speed Operation	
Condition A [a,f]	
Capacity, gpm	4250
Total head, feet	32.46
NPSHA, feet	31.94
Condition B [b,f]	
Capacity, mgd	from pump H/Q curve
Total head, feet	27.15
NPSHA, feet	39.61
Condition B [c,f]	
Capacity, mgd	from pump H/Q curve
Total head, feet	68.15
NPSHA, feet	30.43
Reduced Speed Operation	
Condition D-1 [d,f]	

Capacity, mgd	2250
Total head, feet	20.84
Pump speed	Reduced
NPSHA, feet	40.43
Condition D-2 [d,f]	
Capacity, mgd	2250
Total head, feet	28.93
Pump speed	Reduced
NPSHA, feet	30.43
Condition E [e,f]	Condition E [e,f]
Capacity, mgd	TBD
Total head, feet	TBD
Pump speed	Minimum
NPSHA, feet	TBD

a. *Take Condition A as the rated operating condition. Guarantee performance at the rated condition in accordance with Section 43 23 03. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Select pumps furnished under this section to achieve Condition A performance, and also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and published in the manufacturer's published application data for the specific model proposed for this application.*

b. *Condition B head is presented to indicate operating conditions when the pump is operating at maximum speed against minimum anticipated system head, assuming a hypothetical head-capacity curve. Use Condition B for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ, and shall not be less than 10 percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected. Net positive suction head available (NPSHA), as listed for Condition B is calculated on a pumped flow of [TBD] mgd.*

c. *Condition C represents the pump operating against the backwash tank at maximum flow. The pumps shall operate within the POR if possible.*

d. *Condition D is the anticipated continuous duty minimum speed condition. Provide pumps furnished under this specification capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 43 23 03. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application.*

e. *Condition e represents the expected momentary (startup/shutdown) condition. Pumps furnished under this specification will operate for no more than 30 seconds at this condition when initiating or terminating a service cycle. The maximum anticipated number of service cycles is 12 per day.*

f. *Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1–1.6. NPSHA in the above tabulation is referred to the pump inlet piping at centerline elevation as shown and is calculated in accordance with ANSI/HI 1.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. An allowance of 5 feet has been included for the presence of volatile constituents in the pumped fluid. Required NPSHA margin shall be as specified in Section 43 23 03.*

C. Design requirements:

1. Conform equipment provided under this section to the following:

Item	Value
Pump	70-P-00010 70-P-00020 70-P-00030
Maximum efficiency, minimum, percent [a]	
Bowl	TBD
Pump	TBD
Impeller type	TBD
Piping connection size, inches, minimum	
Discharge	TBD
Minimum bell diameter, inches [b]	TBD
Discharge arrangement	Above
Operating speed, rpm, maximum	TBD
Motor (See Section 43 05 21)	
Horsepower	100
Type (See Section 43 05 21)	Project defined TEFC – (Corrosion) Severe Duty, Enclosed
Inverter duty	Yes
Space heater	Yes
Thermal protection	Yes
Ambient duty rating	+40
Operating speed, rpm, maximum	TBD
Voltage rating	460 volt, 3 Phase
Hazardous rating	None
Reversing motor	No
Multi-speed motor	Yes
Motor starting type	VFD
Voltage rating	460 volt, 3 Phase

Notes:

a. The maximum efficiency is the minimum acceptable peak efficiency and is not required to coincide with any specified operating condition in paragraph 1.01 Performance Requirements. Ensure pump efficiency is as defined in Section 43 23 03. Ensure pump efficiency is within 2 percent of bowl efficiency when calculated at the point of peak bowl efficiency on the pump's head/capacity curve.

b. Select inlet bells in accordance with the requirements of Section 43 23 03.

2. The pumps will be installed in an intake structure designed in accordance with ANSI/HI 9.8, assuming a pump bell velocity of 4.0 feet per second when the pump is operating at the flow produced at the head specified in Operating Condition B. Pumps with inlet velocities less than this value at Operating Condition B are acceptable. If the Contractor proposes a pump with an inlet velocity greater than 4.0 feet per second at the head listed for Operating Condition B, fit a bell extension fitting, or "umbrella" to the pump to achieve this limitation.

2.04 SYSTEM OPERATION

A. Install the pumps in a heated and/or ventilated room at an elevation of 5211' feet above sea level. One pump is a standby pump, while the remainder are duty pumps. Control the pumps by the central plant control system

2.05 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

Component	Material
Impeller, first stage	Nickel aluminum bronze, ASTM B148, C95500
Impeller, all other stages	Nickel aluminum bronze, ASTM B148, C95500
Bowls	NSF 61 approved epoxy coating System E-5 per coating specification Section 09 90 00 for potable water application
Hydrocones	Type 316L stainless steel

2.06 COMPONENTS

A. Bell:
   1. Select a bell that will provide a smooth transition from the diameter specified above under the PERFORMANCE/DESIGN CRITERIA: Design Requirements to the suction case. Provide bolted connections between the bell casting and the suction case. At the manufacturer's option, provide a bell extension fitting or "umbrella" to achieve the specified inlet velocity.

B. Suction case:
   1. Design the suction case to provide conservative entrance velocities and evenly distribute the flow to the impeller. Ensure the inner surface of the case is smooth and free from projections or cavities. House the pump shaft lower bearing in a streamlined casing. Center and hold in place by means of rigid cast vanes. Design the bearing housing and vanes to conduct the flow efficiently into the impeller eye.

C. Pump bowl:
   1. Flange the pump bowl for registered fit. Provide bolted connections between the suction case and the bowl and between the bowl and adjacent stages or the discharge case. Provide diffuser vanes that are not a multiple of impeller vanes. Polish or porcelain-line flow passages through the bowl and diffuser vanes. If required on multi-stage installations, the first-stage bowl may be designed to facilitate a low NPSH impeller arrangement.
   2. If enclosed impellers are specified, provide replaceable wearing rings on the pump bowl at the impeller inlet connection.

D. Impeller:
   1. Construct impellers free from projections, cavities, or abrupt transitions. Polish the impeller surfaces.

2. Select impellers of the enclosed or semi-open type as specified in above under the PERFORMANCE/DESIGN CRITERIA - Design Requirements. If of the enclosed type, fit the shroud with wearing rings. Secure impellers to the pump shaft using tapered collets or keyways.

E. Shafts:
   1. Size shafts to prevent excessive elongation, and to transmit the required torque without distortion in both the forward and reverse direction. Provide shafts with a first critical speed not less than10 percent below and 20 percent above maximum operating speed. Provide pumping units that use a two-piece headshaft, solid intermediate lineshafts supplied in maximum 10-foot lengths, and provide a single pump shaft extending from the suction case through a discharge case or upper bowl case containing an upper pump shaft bearing.
   2. Provide a open lineshaft assembly that is lubricated by the product fluid.

F. Bearings:
   1. Select a suction case, bowl, and lower tube bearings that are close tolerance, spiral-grooved, and sleeve-type. Grease lubricate the suction case bearing. Lubricate bowl sleeve bearings by the pumped fluid. Ensure that bearing spacing does not exceed 5 feet.
   2. Provide bearings that are extra length spiral-grooved sleeve-type, spaced at not more than 5 feet apart. Lubricate the lineshaft bearings using the product fluid.

G. Discharge column:
   1. Fabricate discharge columns with interchangeable pipe sections with flanged joints. Ensure that the column interior is free from offsets, burrs, discontinuities, or irregularities. Supply the column in sections not exceeding 5 feet in length. Provide intermediate spider bushings that align and support the lineshaft enclosure. Provide flanged connections at all column, bowl, and discharge head connections.

H. Discharge head and drive unit support:
   1. Select a discharge elbow of the above-ground type as specified, mitered, or formed to provide a smooth transition from the discharge column to the discharge nozzle. Fit the pump discharge nozzle for connection with a grooved-end pipe coupling or flanged as specified. Fit the discharge head with the specified shaft seal, located to afford convenient access for maintenance. Support the elbow by a fabricated steel baseplate reinforced with ribs designed to carry the weight of the complete pump and drive unit without distortion when spanning an opening sufficient to permit withdrawal of the complete pump without removing the bowl or inlet bell. Cast or fabricate the drive unit support out of steel, and design to accommodate the equipment specified. Provide brackets, cartridges, and drilled ports as required for all monitoring devices specified in Division 40. Design the support in accordance with Section 43 23 03 and for seismic zone in accordance with Section 01 73 24.
   2. Provide the pump head with a soleplate conforming to Section 43 05 13, manufactured expressly for the discharge head provided.

I. Seal:
   1. Provide a mechanical seal conforming to the requirements of Section 43 05 11-2.04 Mechanical Seals. Provide drilled and tapped connections for connection to an external source of lubricating fluid, if required.

J. Couplings:
   1. Provide a four-piece coupling to connect the motor shaft and headshaft between the motor and the tension nut assembly. Design the four-piece coupling to provide for impeller adjustment, and include a spacer to permit servicing the seal.
   2. Provide lineshaft couplings that are a perfect butt-fit. Design with a safety factor of 1-1/2 times the shaft safety factor and shall have a left-hand thread to tighten during pump operation.

K. Corrosion protection:
   1. Protect the interior of the discharge column, discharge head, and all exterior below grade surfaces of the pump with coating system TBD as specified in Section 09 90 00.

L. Drive unit:
   1. Drive the pump by a vertical solid-shaft motor conforming to PERFORMANCE/DESIGN CRITERIA: Design Requirements specified above, Section 43 05 21, and the requirements of Section 43 23 03. Non-reverse ratchet-equipped motors will not be accepted.

M. Variable frequency drive:
   1. Furnish the pump with a VFD as specified in Section 26 29 23.

N. Equipment mounts:
   1. Mounting plates: Fabricated steel (stress relieved after fabrication) or cast iron per Section 43 05 13 with provisions for bolting each machine and sufficient thickness to permit dowelling.

2.07 CONTROLS

A. Refer to Division 40 specifications for further control information.

2.08 CONTROL PANELS

A. Refer to Division 26 Sections for further information.

2.09 FINISHES

A. Procedures: Section 09 90 00.

B. Prime coat: Shop applied, coating material per NSF 61.

C. Finish coat: Field applied, coating material per NSF 61.

2.10 SOURCE QUALITY CONTROL

A. Factory testing shall be non-witnessed in accordance with Section 43 23 03.

B. Hydrostatic tests:
   1. Factory test all pressure sustaining parts in accordance with Section 43 23 03.

C. Performance tests:
   1. Subject each pump to non-witnessed performance test in accordance with Section 43 23 03 to verify the full range of operating condition

PART 3 EXECUTION

3.01 EQUIPMENT MOUNTING

A. Procedure: Section 43 05 13.

B. Position equipment pad and equipment anchors for final placement of equipment.

C. Use a bolting template to position equipment anchors.

D. Level baseplate.

E. Pour grout bed supporting baseplate.

F. Eliminate grout voids below baseplate as applicable.

G. Tension equipment anchors.

H. Provide completed Form 43 05 13-A, Section 01 99 00, for each equipment installation.

3.02 ALIGNMENT

A. Procedures: Section 43 05 14.

3.03 FIELD QUALITY CONTROL

A. Field testing:
   1. Lateral vibration testing in accordance with Section 43 23 03.
   2. Torsional vibration testing in accordance with Section 43 23 03. Torsional testing performed by Design Professional.
   3. Include in the bid all costs for services of Testing Firms and Design Professionals performing these services.

B. Manufacturer services:
   1. On-site inspections and training: Provide a factory-trained manufacturer's representative at the site for the following activities. Specified durations do not include travel time to or from the site.
      a. Installation inspections: Assist, supervise, and inspect the Contractor's activities during installation. Provide 16 inspection hours. Provide a completed Form 43 05 11-A, Section 01 99 90.
      b. Component test phase inspections: Assist, supervise, and inspect the Contractor's activities during the system test phase specified in Section 01 45 20 and this section. Provide 16 inspection hours.
      c. Operational test phase inspections: Assist, supervise, and inspect the Contractor's activities during the operational test phase specified in Section 01 45 20 Provide 16 inspection hours.

d. Training sessions: Procedures Section 01 79 00. Provide a minimum of 4 hours classroom training for each training session. Conduct one training session to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 43 05 11-B, Section 01 99 90.

3.04 SYSTEMS STARTUP

A. Procedures: Section 01 45 20.

B. Preoperational (factory) testing; See paragraphs 1.07 and 2.11.

C. Component testing: Perform the following tests:
   1. During initial pump installation, verify on one pump that the crane system has the clearance and capacity to lift the wetted-end from the field mounted pump volute to accommodate routine pump maintenance. Provide or modify spreader bar or lifting assemblies as necessary to accomplish this task.
   2. During initial pumping system installation, verify with clean water that the common pump discharge header, and the individual pump suction elbows can be readily drained to the pump room sump for maintenance or pump de-ragging without spilling on to the pump room floor.
   3. Complete lateral vibration testing of all pumps in accordance with Section 43 23 03.

END OF SECTION

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SECTION 43 23 80.12

SUBMERSIBLE WATER PUMPS – CONSTANT SPEED SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies submersible pumps installed in a wet pit configuration suitable for pumping fluids containing water treatment residual solids at constant speed. Pumps furnished under this specification shall have discharge nozzles 4 inches in diameter and smaller, motors less than 7.5 horsepower.

   .

2. Pump units shall be complete with motor, discharge fitting, guide bar and brackets, chain and cable hooks and other accessories as specified. Each submersible pump will have a sump access frame, hatch and fall protection system as provided under Section 08 31 20.
3. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.

B. Type:

1. Pumps shall be of the submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing water treatment residual solids. The pumps shall be designed for continuous or cyclic operation under submerged, or partially submerged without damage to the pump and motor. Special attention shall be devoted to the shaft design to limit deflection under all operating conditions, as specified in this section.

C. Equipment List:

Item	Equipment Number
INFILTRATION GALLERY PUMP 1	01-P-00010
INFILTRATION GALLERY PUMP 2	01-P-00020
TREATMENT BUILDING RECYCLE PUMP 1	35-P-00050
TREATMENT BUILDING RECYCLE PUMP 2	35-P-00060
TREATMENT BUILDING DRAINAGE PUMP 1	35-P-00100
TREATMENT BUILDING DRAINAGE PUMP 2	35-P-00110
STRUCTURAL UNDERDRAIN PUMP 1	70-P-00020
STRUCTURAL UNDERDRAIN PUMP 2	70-P-00030

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 78 23 Operation and Maintenance Data
2. Section 01 79 00 Demonstration and Training

3. Section 01 91 00 Commissioning, Testing and Startup
4. Section 01 99 90 Reference Forms
5. Section 08 31 20 Floor Access Doors.
6. Section 43 05 11 General Requirements for Equipment.
7. Section 43 05 13 Rigid Equipment Mounts.
8. Section 43 05 21 Common Motor Requirements for Equipment.

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
ASTM A48	Gray Iron Castings
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
UL 674	Motors and Generators, Electric, for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F, and G

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. See Section 01 12 16: Work Sequence.

B. Unit Responsibility:
   1. Assign unit responsibility, as specified in Section 43 05 11, to the manufacturer of the vertical, nonclog submersible pumps provided for all equipment and accessories under this section. Have all mechanical equipment components, at least, of this entire equipment assembly furnished by the pump's manufacturer. Provide a completed, signed, and notarized Certificate of Unit Responsibility (Form 43 05 11-C, Section 01 99 90).

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.

2. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
    a. This Section (43 23 80.12)
    b. Section 43 05 11 – General Requirements for Equipment
    c. Section 43 05 13 – Rigid Equipment Mounts
    d. Section 43 05 21 – Common Motor Requirements for Equipment
3. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Unit Responsibility Certification form (Form 43 05 11-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.
6. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the ordinate plotted against capacity on the abscissa. All curves shall clearly display the specified operating conditions, POR and the manufacturer's limits for the AOR.
7. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.
8. Manufacturer's data including materials of construction and equipment weight.
9. Motor Data Form 43 05 21 -A.
10. Manufacturer's operation and maintenance information in accordance with Section 01 78 23.
11. Installation Forms in accordance with Section 43 05 11.
12. Testing Forms in accordance with Section 01 99 90.

B. Informational Submittals:
    1. NOT USED

C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 01 78 23.
   2. Spare parts:
      a. Procedures: Section 43 05 11. Provide the following spare parts for each model and size of pump furnished for this Section:
         1) One complete set of all gaskets and seals.
         2) One complete sets of all bearings.
         3) One complete set of mechanical seals.
         4) One complete set of discharge connection sealing devices.
         5) One complete spare pump.

1.06 QUALITY ASSURANCE

A. Vibration Limits: Vibration limits for submersible pumps shall be in accordance with ANSI/HI 11.6.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Block shaft and prevent damage to bearings during shipment.

1.08 MANUFACTURER'S REPRESENTATIVE

A. Field services shall be performed by qualified personnel with at least five (5) years experience providing field services for similar equipment installation for System Supplier.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Xylem – Flygt
   2. Sulzer – ABS
   3. Or Approved Equal

2.02 TYPE

A. Submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing water treatment residual solids.

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:

Description	
Equipment number	05-P-00010 05-P-00020 35-P-00050 35-P-00060 35-P-00100 35-P-00110 70-P-00020 70-P-00030
Area exposure	Per Section 01 61 45
Fluid type	Water treatment residual solids containing up 600 mg per liter of suspended solids consisting of organic and inorganic materials, and grit (sand, activated carbon).
Fluid temperature	40 to 75 degrees F

B. Operating Conditions:

1. The performance requirements presented in tabular form below are intended to describe the results of hydraulic calculations developed using a mathematical modeling program specifically developed for the purpose. The model was intentionally used to develop the limits of expected extremes in variation of static head, coefficients for pipeline resistance and turbulence losses through fittings and valves.
2. Equipment furnished under this section shall be fully suitable for continuous operation at any specified condition or any condition lying between the extremes of the operating conditions specified in the following table. The total head in the information below is the total system head at the operating capacity, essentially a summation of the head of the two pumps at that capacity. The notes presented at the end of the table are intended to be complimentary to the information presented in the table.

C. Table of Operating Conditions:

Operating Condition	Value	Value	Value	Value
Equipment number	05-P-00010 05-P-00020	35-P-00050 35-P-00060	35-P-00100 35-P-00110	70-P-00020 70-P-00030
Condition A [1,3]				
Capacity, gpm	206.5	50	25	200
Total head, feet	45.9	20.0	10.0	31.0
NPSHA, feet	6.76	-	-	-
Condition B [2,3]		50	25	200
Capacity, gpm	207.6	From pump H/Q curve (300 gpm max)	From pump H/Q curve (300 gpm max)	From pump H/Q curve (300 gpm max)

Operating Condition	Value	Value	Value	Value
Equipment number	05-P-00010 05-P-00020	35-P-00050 35-P-00060	35-P-00100 35-P-00110	70-P-00020 70-P-00030
Total head, feet	29.1	20.0	10.0	31.0
NPSHA, feet [4]	6.78	N/A	N/A	N/A

Notes:

1. *Condition A shall be taken as the rated, continuous-duty operating condition. Performance at the rated condition shall be guaranteed in accordance with Section 43 23 03. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section shall be selected to achieve Condition A performance, and also shall operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer's published application data for the specific model proposed for this application.*
2. *Condition B head is presented to indicate operating conditions when the pump is operating against minimum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ and shall be not less than 60 percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. NPSHA, as listed for Condition B is calculated on a pumped flow as listed in the table.*
3. *Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1 through 1.6. Net positive suction head available (NPSHA) in the above*
4. *Flow rate provided in parentheses for Condition B represents the flow rate at which NPSHA is calculated. Also refer to Note 3.*

D. Design Requirements:

Item	Value	Value	Value	Value
Equipment number	01-P-00010 01-P-00020	35-P-00050 35-P-00060	35-P-00100 35-P-00110	70-P-00020 70-P-00030
Pump				
Rigid sphere, inches diameter (min.), capable of passing through the pump from inlet to discharge (Impeller Alternate 1/Alternate 2)	2/1.5	2/1.5	2/1.5	2/1.5
Minimum efficiency at best efficiency point (BEP) at maximum speed, percent[1]	60	30	30	60
Piping connection size, inches, minimum				
Pump discharge	3.0	2.0	1.0	1.0
Operating speed, rpm, maximum	1,779	-	-	-
Operating speed, constant or variable	constant	constant	constant	constant

Item	Value	Value	Value	Value
Equipment number	01-P-00010 01-P-00020	35-P-00050 35-P-00060	35-P-00100 35-P-00110	70-P-00020 70-P-00030
Suction specific speed, dimensionless, maximum[2]	9,000	9,000	9,000	9,000
Motor				
Horsepower	6.0	1.0	1.0	6.0
Type	Submersible	Submersible	Submersible	Submersible
Over temperature protection	Yes	Yes	Yes	Yes
Moisture sensors	Yes	Yes	Yes	Yes
Operating speed, rpm, maximum	1,779	-	-	-
Voltage/Phase	460 VAC, 3 Phase	460 VAC, 3 Phase	460 VAC, 3 Phase	460 VAC, 3 Phase

Notes:

1. *The minimum acceptable efficiency at best efficiency point (BEP) at the speed required to achieve the performance specified under Condition Points A and B. The minimum acceptable efficiency is not necessarily required to be associated with any operating condition specified in paragraph 2.03 Operating Conditions.*
2. *The suction specific speed limitation listed applies only to pump selections where both Operating Conditions A and B reside within the proposed pump selection's POR. Proposed selections with Operating Condition A residing in the AOR shall be limited to designs with suction specific speed less than 8500. Suction specific speed shall be calculated for the maximum pump design speed and impeller diameter, using the capacity in gallons per minute and NPSH3 at Best Efficiency in accordance with the procedures set for in the standards of the Hydraulic Institute.*

2.04 SYSTEM OPERATION

A. The pumps will be operated automatically by the control panel specified in this section in a Lead/Lag configuration to empty the sump based on level switches in the sump.

B. The pumps will be operated by a control system that will start and stop the pumps at constant speed to control wet well liquid surface elevation. Periodically, the control system will be overridden permitting the wet well level to be drawn down until the pumps break suction.

C. The pumps will be installed in a ventilated reinforced concrete structure designed to provide sufficient space for access to install and remove the equipment.

2.05 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Provide materials of construction in accordance with the following table:

Component	Material
Pump and motor casing	
Rated head < 100 feet	Cast iron, ASTM A48, Class 30 or 35
Rated head > 100 feet	Cast ductile iron, ASTM A 536, Class 65-45-12
Discharge elbow	Cast iron, ASTM A48, Class 30 or 35
Impeller	Cast iron, ASTM A48, Class 30 or 35 or ASTM A532-IIIA
Motor and pump shaft	Stainless steel, ASTM A276 Type 329, 403, 416, 420 or ASTM A479 Type 403, 431
Wearing rings	Stainless steel, ASTM A276 Series 440B or Cast duplex stainless steel, ASTM A890 Grade 1B or 5A
External bolts and nuts	Stainless steel, ASTM A276 Type 316
Guide bar brackets	Stainless steel, ASTM A276 Type 316
Anchor bolts	Stainless steel, ASTM A276 Type 316
Guide rails, lifting assemblies	Stainless steel, ASTM A276 Type 316

2.06 COMPONENTS

A. Pumps and Motor Casing:

1. Casings shall be constructed of corrosion resistant cast iron and shall be designed to allow removal of all rotating parts from the motor end of the pumps. All mating surfaces where watertight sealing is required shall be machined and fitted with nitrile O-rings. Casing shall be fitted with moisture sensor specifically designed to detect the presence of water in the seal chamber.

B. Impellers:

1. Alternate 1: The impeller shall be dynamically balanced with a non-clogging design capable of passing solids, fibrous materials, coarse solids, and other matter found in normal water applications through to the discharge nozzle. Impellers for pumps with discharge nozzles 4 inches in diameter and greater shall be not less than two-vane design. Fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw that is threaded into the end of the shaft, or a slip fit onto the shaft and drive key and fastened to the shaft by an impeller nut having cover for protection from pumped fluid. A wearing ring system designed for abrasion resistance shall provide efficient sealing between the volute and impeller.
2. Alternate 2: The impeller shall be dynamically balanced, semi-open, multi- vane, back-swept, non-clog design. The impeller vane leading edges shall be mechanically self-cleaned upon each rotation as they pass across a spiral groove located on the volute suction which shall keep them clear of debris, maintaining an unobstructed leading edge. The impeller(s) vanes shall have screw-shaped leading edges that are hardened to Rc 45 and shall be capable of handling solids, fibrous materials, coarse solids and other matter found in water and potable water. The screw shape of the impeller inlet shall provide an inducing effect for the handling of water treatment residual solids ladened water. Impellers shall be locked to the shaft and shall be coated with alkyd resin primer.

C. Bearings:
   1. Bearings shall be heavy-duty permanently lubricated ball type. Bearings shall be designed for an L-10 life of 50,000 hours heavy-duty service without requiring additional lubrication.

D. Shaft:
   1. The pump shaft shall be turned, ground and polished, of proportions suitable for use in the specified application. The shaft shall be of sufficient section to limit deflection at the shaft seal to not more than 4.0 mils when the pump is operating at any continuous-duty point defined by the envelope of conditions specified in this Section.

E. Mechanical Seals:
   1. Provide tandem or dual mechanical seals per the following requirements:
      a. Dual cartridge
      b. High-capacity barrier fluid ports
      c. Self-centering, non-fretting
      d. Springs isolated from both process and barrier fluids
      e. Pressure Rating: 250 psig
      f. Stationary Face: silicon carbide
      g. Rotary Face: silicon carbide
      h. Metal Parts: Type 316 stainless steel
      i. Springs: Hastelloy C
      j. O-Rings: fluorocarbon
      k. Candidate Product: Chesterton 255 or approved substitute

F. Motor:
   1. The motor shall be designed to be non-overloading over the entire pump curve. The motor housing shall be of submersible construction with the windings operating in a sealed environment. Motors shall be either air or dielectric oil filled with built-in automatic reset overload protection. Motors in hazardous locations shall be UL listed in accordance with UL 674 for Class I, Group D hazardous atmosphere. The motor shall be provided with motor windings thermostats, one in each winding, to protect the motor from overheating.

G. Cable:
   1. Pump motor and detector cables shall be suitable for submersible pump applications. Pump motor and detector cables may be combined into one assembly or separate as standard for the pump manufacturer. Each cable shall be a heavy-duty, flexible, water-resistant portable, UL listed cable, sealed at the motor bell and of sufficient length to connect to the associated sump pump control panel. The cable entry into the motor shall be comprised of a singles cylinder elastomer grommet and shall prevent water from leaking into the motor due to capillary action even if cable is cut or damaged. Cables shall be watertight to a minimum depth of 65 feet.

H. Guide Rail Lifting System and Discharge Elbow:

1. The pump shall be provided with a dual guide rail system to allow easy removal of the pump without entering the wet well. The discharge connection shall be bolted to the structure as required by the pump manufacturer and shall serve as a lower attachment for the guide rails. The discharge connection shall be an elbow discharge type.
2. The pump and guide rail system shall be designed to automatically connect the pump to the discharge piping when lowered into place on the discharge connection. The design shall be non-sparking and shall conform to UL requirements for installation in a location classified in accordance with NFPA 70, Article 500 for Class 1, Group D, Division 1 locations. When in place, the connection shall form a watertight seal with the discharge fitting. The pump shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose. Sealing of the pumping unit to the discharge connection shall be accomplished by a simple linear downward motion of the pump with the entire weight of the pumping unit guided to and pressing tightly against the discharge connections. No portion of the pump shall bear directly on the floor of the sump and no rotary motion of the pump shall be required for sealing. Once the pump has been positioned on its support fitting at the discharge fitting, the guide bar system shall not be required for pump support.
3. The pump shall be provided with a lifting chain, guide bars, upper guide bar brackets, intermediate guide bar brackets, cable holder assemblies, safety chain hook assemblies, discharge elbow connections, anchor bolts, and all other accessories necessary to complete the installation as specified. The lifting chain length shall equal the depth of the sump.

I. Level Instruments:

1. Provide level instruments to meet the pump control operation requirements defined in this section. Level instruments shall meet the requirements of Section 40 72 00. Provide cable of sufficient length to reach the control panel from the sump.

2.07 CONTROL PANEL

A. General:

1. Panels shall be provided with instruments used for control, monitoring, and alarming. The control panel for the sump pumps shall be designed in accordance with Section 40 67 00, the contract P&ID drawings, and to support the specified operation.

B. Sump pump control panels shall be rated NEMA 4X for non-hazardous locations and NEMA 7 for use in hazardous locations.

C. Features:

1. Panels shall be provided with instruments used for control, monitoring, and alarming.
2. Control shall include HAND/OFF/AUTO mode selection, pump **LEAD/LAG**, motor protection, and reset button to clear motor protection alarms.
3. Panels shall contain distribution components, power supplies, and transformers, as required, to derive power for all instruments and equipment provided as part of the pump package.
4. Separate pump and control circuit breaker with intrinsically safe module for floats.

5. Dry contact and panel lights for pump running, pump fail, moisture sensor, motor over temperature, and high-level alarm.
6. Suitable for service from a single 480V ac, three-phase service.
7. Provide intrinsically safe relays for use with the level switches to meet hazardous ratings.
8. Pump protection relay for each pump for connecting the motor leak and temperature detectors.
9. Internal enclosure heater.
10. Terminal strip for connection of external devices.
11. Motor starter per Division 26.
12. External Signal Interface: Provide dry contact closures for connection to the Plant Control System rated 0.5 amps at 12 or 24 Vdc for the following conditions:
    a. Each pump's running status.
    b. Pump fault signal
    c. Low, Mid and High level signals
    d. Each pump ready status. Ready status is panel has power and pumps set to AUTO mode with no active alarms present.
    e. Moisture alarm
    f. Motor winding alarm

D. Pump Control Operation:
1. Provide controls for the following pump Operation.
    a. Start the selected lead pump at the LSL level setting.
    b. Start the selected lag pump at the LSH level setting.
    c. Alarm and start both pumps at the LSHH level setting.
    d. Shut down both pumps at the LSL level setting.
2. Pump Protection Controls:
    a. Moisture sensor shall be wired to activate an indicator in the local control panel and to send an alarm to the Plant Control System. Upon detection of moisture the alarm shall be activated, but the pump shall be allowed to run.
    b. Temperature switch shall be wired to disable the pump if excessive heat is detected and send an alarm to the Plant Control System. The thermostats shall reset automatically after the motor windings have cooled down. Provide provision for manual reset of the motor.

2.08 FINISHES

A. Procedures: Section 09 90 00

B. Prime Coat: Shop applied, manufacturer's standard coating system.

C. Finish Coat: Shop applied, manufacturer's standard coating system

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Factory tests will not be required. However, the manufacturer shall guarantee the performance specified under paragraph 43 23 80.12-2.03, Condition A.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Procedures: Section 01 45 00 and Section 01 91 00.

B. Perform the following test:
   1. Performance Test
      a. Using clean water, measure pump flow and discharge pressure. Verify pump flow and discharge pressure is within the range of specified operating conditions.
      b. Temporary flow meters and pressure gauges will be required.
      c. Throttle valve on pump discharge as necessary to achieve specified pump pressure within specified operating range.
      d. Test level controls to verify pump control system operates as specified in this Section.

3.02 MANUFACTURER'S SERVICES

A. On-Site Inspections and Training: Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
   1. Installation Inspections: Assist, supervise, and inspect the Contractor's activities during installation of submersible sump pumps. Provide 4 hours of installation inspection during installation of each submersible sump pumps.
   2. Training Sessions: Procedures Section 01 79 00. Provide 2 hours of classroom training. Complete Form 43 05 11-B, Section 01 99 90.

END OF SECTION

SECTION 43 23 80.14

SUBMERSIBLE WATER PUMPS - VARIABLE SPEED

PART 1 GENERAL

1.01 SUMMARY

A. Scope:
   1. This section specifies submersible pumps installed in a wet-pit configuration suitable for pumping fluids containing potable water treatment residual solids at infinitely variable speed.
   2. Pump units shall be complete with motor, discharge fitting, guide bar and brackets, chain and cable hooks and other accessories as specified. Each submersible pump will have a sump access frame, hatch and fall protection system as provided under Section 08 31 20.
   3. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.
   4. Equipment shall additionally conform to the requirements of Section 43 23 03 with the exception that provisions of Section 43 23 03-1.05 and Section 43 23 03-1.07 do not apply unless of specifically called out in this project specification.
   5. Control panel shall comply with Division 40 specifications.
   6. Backwash Transfer pumps shall have been certified to meet the following requirements for potable drinking water applications:
      a. NSF/ANSI/CAN 61 for drinking water system components.
      b. NSF/ANSI/CAN 372 for lead content.

B. Type:
   1. Pumps shall be of the heavy-duty, submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing potable water treatment residual solids. The pumps shall be designed for continuous or cyclic operation under submerged, partially submerged or totally dry condition without damage to the pump and motor. Special attention shall be devoted to the shaft design to limit deflection under all operating conditions, as specified in this section.

C. Equipment List:

Item	Equipment Number
RECYCLED WATER PUMP 1	60-P-00010
RECYCLED WATER PUMP 2	60-P-00020

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 08 31 20 Floor Access Doors

2. Section 26 29 23 Variable Frequency Motor Controllers
3. Section 43 23 03 General Requirements for Centrifugal and Axial Flow Pumping
4. Section 43 05 11 General Requirements for Equipment
5. Section 43 05 13 Rigid Equipment Mounts
6. Section 43 05 21 Common Motor Requirements for Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. References shall be as listed in Section 43 23 03.

C. Additional references shall be as follows:

Reference	Title
NSF/ANSI/CAN 61	Requirements for drinking water system components
NSF/ANSI/CAN 372	Requirements for lead content

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment Pad: concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade
   2. Mounting Pads: thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate]

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. See Section 01 12 16: Work Sequence.
   2. Coordinate pump and motor operational and starting characteristics with adjustable-frequency drive settings used for control of this equipment. A system curve is available upon request from the Construction Manager. Include the following:
      a. Motor minimum operational speed
      b. Motor maximum operational speed
      c. Motor ramp-up and ramp-down speed, voltage, and hertz requirements
      d. Other operating limits that are imposed by the driven equipment for operation and warranty

B. Unit Responsibility:

1. Assign unit responsibility, as specified in Section 43 05 11, to the manufacturer of the vertical, nonclog submersible pumps provided for all equipment and accessories under this section. Have all mechanical equipment components, at least, of this entire equipment assembly furnished by the pump's manufacturer. Provide a completed, signed, and notarized Certificate of Unit Responsibility (Form 43 05 11-C, Section 43 05 11). Additionally, the manufacturer shall review submittal data for the variable speed drive units that are proposed by the Contractor under Section 26 29 23. The manufacturer shall submit a letter indicating whether the proposed units are satisfactory or not for use with the pumps in this section.

1.06 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. Submittals shall conform to the requirements of Section 43 23 03. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   a. This Section (43 23 80.14)
   b. Section 43 05 11 – General Requirements for Equipment
   c. Section 43 05 13 – Rigid Equipment Mounts
   d. Section 43 05 21 – Common Motor Requirements for Equipment
   e. Section 43 23 03 – General Requirements for Centrifugal and Axial Flow Pumping Equipment
3. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Unit Responsibility Certification form (Form 43 05 11-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.

6. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the ordinate plotted against capacity on the abscissa. Curves shall be provided to demonstrate operation at all speeds required to achieve the specified reduced speed operating conditions. All curves shall clearly display the specified operating conditions, POR and the manufacturer's limits for the AOR.
7. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.
8. Manufacturer's data including materials of construction and equipment weight.
9. Motor Data Form 43 05 21 -A.
10. Proof of service of previously installed units of similar size and configuration in wet wells of the type specified in this Section.
11. Written factory tests report, as specified in paragraph 2.09.
12. Shaft deflection calculations.
13. Anchorage calculations and required documentation.
14. Cooling system calculations.
15. Manufacturer's operation and maintenance information in accordance with Section 01 78 23.
16. Installation Forms in accordance with Section 43 05 11.
17. 5-Year warrantee in accordance with paragraph 1.09.
18. Testing Forms in accordance with Section 01 99 90.
19. Field vibration test protocol as specified in ANSI/HI 11.6.
20. Field discharge connection leakage test video files in accordance with paragraph 3.03.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Submittals shall conform to the requirements of Section 43 23 03.
   3. Letter of confirmation of suitability of variable frequency drives being provided by the Contractor for this equipment in accordance with Section 26 29 23.
   4. Coordination items required for proper setup of the variable frequency driver as specified in paragraph 1.05.A. Coordination.
   5. Letter of confirmation of listed NSF/ANSI/CAN certification of equipment for potable water use and operation.

C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 01 78 23.
   2. Spare parts:
      a. Procedures: Section 43 05 11. Provide the following spare parts for each model and size of pump furnished for this Section:
      b. One complete set of all gaskets and seals
      c. Two complete sets of all bearings

d. Two complete sets of mechanical seals
e. Two complete sets of discharge connection sealing devices
f. One removable cable seal chamber cap with cable length as required in this Section.
g. If oil-filled motor is furnished, provide spare oil in sufficient quantity to allow for one-time flushing and replacement of coolant for all installed pumps.

1.07 QUALITY ASSURANCE

A. Qualifications:
   1. Independent testing agent hired by the Contractor for field vibration testing: Section 43 23 03.

B. Critical Speeds: Critical Speeds shall be in accordance with Section 43 23 03-1.04.

C. Vibration Limits: Vibration limits for submersible pumps shall be in accordance with ANSI/HI 11.6. Field testing shall be in accordance with paragraph 3.03 of this section.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00

B. Block shaft and prevent damage to bearings during shipment.

1.09 SPECIAL WARRANTY

A. Provide a Special 5-Year Warranty. The manufacturer shall warrantee the pumps provided under this section against defects in materials and workmanship for 5 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Xylem - Flygt
   2. KSB
   3. Sulzer – ABS
   4. Pentair
   5. Approved Equal

2.02 TYPE

A. Heavy-duty, submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing potable water treatment residual solids.

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:

Description	
Equipment number	60-P-00010 60-P-00020
Area exposure	Per Section 01 61 45
Fluid type	Potable water treatment residual solids containing up 600 mg per liter of suspended solids consisting of organic and inorganic materials, and grit (sand, activated carbon).
Fluid temperature	40 to 75 degrees F

B. Operating Conditions:

1. The performance requirements presented in tabular form below are intended to describe the results of hydraulic calculations developed using a mathematical modeling program specifically developed for the purpose. The model was intentionally used to develop the limits of expected extremes in variation of static head, coefficients for pipeline resistance and turbulence losses through fittings and valves.
2. Equipment furnished under this section shall be fully suitable for continuous operation at any specified condition or any condition lying between the extremes of the operating conditions specified in the following table. The total head in the information below is the total system head at the operating capacity, essentially a summation of the head of the two pumps at that capacity. The notes presented at the end of the table are intended to be complimentary to the information presented in the table.

C. Table of Operating Conditions:

Operating Condition	Value	Value
Equipment number	60-P-00010	60-P-00020
Full-speed or reduced speed operation, Condition A [1,5]		
Capacity, gpm	550	550
Total head, feet	39.4	39.4
NPSHA, feet	Ample	Ample
Full-speed operation, Condition B [2,5]		
Capacity, gpm	1275	1275
Total head, feet	47.8	47.8
NPSHA, feet (flow basis, gpm)	Ample	Ample
Reduced-speed operation, Condition C [3,5]		
Capacity, gpm	233	233
Total head, feet	34.4	34.4
NPSHA, feet	Ample	Ample

1. *Condition A shall be taken as the rated operating condition. Performance at the rated condition shall be guaranteed in accordance with Section 43 23 03. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section shall be selected to achieve Condition A performance, and also shall operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer's published application data for the specific model proposed for this application.*
2. *Condition B head is presented to indicate operating conditions when the pump is operating at maximum speed against minimum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ and shall be not less than 60 percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected. NPSHA, as listed for Condition B is calculated on a pumped flow of as listed for each pump.*
3. *Condition C is the anticipated continuous duty minimum speed condition. Pumps furnished under this specification shall be capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 43 23 03. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*
4. *Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1 – 1.6. Net positive suction head available (NPSHA) in the above tabulation is referred to the pump inlet centerline elevation as shown and is calculated in accordance with ANSI/HI 1.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. An allowance of five feet has been included for the presence of volatile constituents in the pumped fluid. Required NPSHA margin shall be as specified in Section 43 23 03.*

D. Design Requirements:

Item	Value	Value
Equipment number	60-P-00010	60-P-00020
Pump	Recycled Water Pump 1	Recycled Water Pump 2
Rigid sphere, inches diameter (min.), capable of passing through the pump from inlet to discharge (Impeller Alternate 1/Alternate 2)	3.25	3.25
Minimum efficiency at best efficiency point (BEP) at maximum speed, percent [1]	69.02	69.02
Piping connection size, inches, minimum		
Pump discharge	8.0	8.0
Operating speed, rpm, maximum	1731	1731
Operating speed, constant or variable	Variable	Variable
Approximate pump suction centerline elevation, feet, NAVD 88	5295.1	5295.1
Maximum expected surge pressure, ft	N/A	N/A
Suction specific speed, dimensionless, maximum[2]	-	-
Motor		
Horsepower	25.0	25.0
Type	Submersible	Submersible
Inverter duty	-	-
Space heater	No	No
Over temperature protection	Yes	Yes
Moisture sensors	Yes	Yes
Operating speed, rpm, maximum	1750	1750
Voltage/Phase	460 VAC, 3 Phase	460 VAC, 3 Phase

Notes:

1. *The minimum acceptable efficiency at best efficiency point (BEP) at the speed required to achieve the performance specified under Condition Points A and B. The minimum acceptable efficiency is not necessarily required to be associated with any operating condition specified in paragraph 2.03 Operating Conditions.*
2. *The suction specific speed limitation listed applies only to pump selections where both Operating Conditions A and B reside within the proposed pump selection's POR. Proposed selections with Operating Condition A residing in the AOR shall be limited to designs with suction specific speed less than 8500. Suction specific speed shall be calculated for the maximum pump design speed and impeller diameter, using the capacity in gallons per minute and NPSH3 at Best Efficiency in accordance with the procedures set for in the standards of the Hydraulic Institute.*

   Surge pressure estimated at 10 second valve closure.

2.04 SYSTEM OPERATION

A. The pumps will be installed in a ventilated reinforced concrete structure designed to provide sufficient space for access to install and remove the equipment. The pumps will be operated at variable speed, responding to a control system that will cycle and vary the speed of the pumps in accordance with the specified program. Under normal operation, there will be no cascade into the wet well and the wet well level will vary between the levels indicated.

B. The pumps will be operated by a control system configured to control wet well liquid surface elevation. This objective will be achieved by adjusting pump speed to match the pumping rate to the rate of inflow into the wet well. The pump drives will be adjusted to establish minimum speed when the wet well is at preset low elevation. Pump speed control increments and sequenced starts of additional pumps will be initiated based on rising wet well level. Pumps will be at maximum speed when the liquid level is at the preset maximum level. (I&C: Very difficult to maintain a surface elevation on level switches alone as it's shown now.)

C. System controls allow for wet well cleaning. At intervals estimated to be nominally one week in length, but possibly as little as three days, operating staff will manipulate station wet well level controls to lower the wet well level to clean the wet well of accumulated solids. Solids will be removed from the wet well by operating the pumps until they break suction. Equipment furnished under this section shall be specifically certified by the pump manufacturer as suitable for operation in trench type wet wells where the wet well will be cleaned using the pumping equipment. (I&C: Confirm that wet well cleaning is going to be performed on a regular basis or at all.)

2.05 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion and providing compliance with NSF Lead-Free requirements. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Provide materials of construction in accordance with the following table:

Component	Material
Pump and motor casing	
Rated head < 100 feet	Cast iron, ASTM A48, Class 30 or 35
Rated head > 100 feet	Cast ductile iron, ASTM A 536, Class 65-45-12
Discharge elbow	Cast iron, ASTM A48, Class 30 or 35
Impeller	Cast duplex stainless steel, ASTM A744 or European standard 1.4474, or Cast duplex stainless steel, ASTM A890 Grade 1B, or Hard Chrome Iron ASTM A532-IIIA
Motor and pump shaft	Stainless steel, ASTM A276 Type 329, 403, 416, 420 or ASTM A479 Type 403, 431
Wearing rings	Stainless steel, ASTM A276 Series 440B or Cast duplex stainless steel, ASTM A890 Grade 1B or 5A
External bolts and nuts	Stainless steel, ASTM A276 Type 316
Guide bar brackets	Stainless steel, ASTM A276 Type 316
Anchor bolts	Stainless steel, ASTM A276 Type 316
Guide rails, lifting assemblies	Stainless steel, ASTM A276 Type 316

2.06 COMPONENTS

A. General:

1. The motor and rotating parts shall be removable from the motor end of the pump. All motor mating surfaces where watertight sealing is required shall be machined and fitted with nitrile O-rings. The pump shall be fitted with a dynamically balanced nonclog impeller designed to pass coarse solids and stringy materials. The pump shall be listed by Factory Mutual or Underwriters Laboratory as conforming in all respects to the requirements in UL 1207.

B. Casing:
   1. The volute casing shall be a one-piece casting with a tangential or center discharge nozzle. The volute shall be designed for efficient conversion of kinetic to potential energy and shall have clear passageways designed to pass the solid sphere specified in this Section. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with this Section. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with paragraph 3.03.
   2. The cutwater shall be specifically designed for use in fluids with stringy materials. The volute casting shall be specifically designed to bear the loads associated with removal and placement of the pump when submerged or exposed and to withstand the loads imposed by the operations specified in this Section. The discharge nozzle shall be not less than the diameter specified in this Section and shall be reinforced for the loads imposed by the specified conditions of service. The nozzle flange face shall be designed to mate with the discharge fitting specified in this Section.

C. Shaft:
   1. The pump shaft shall be turned, ground and polished, of proportions suitable for use in the specified application. The shaft shall be of sufficient section to limit deflection at the shaft seal to not more than 4.0 mils when the pump is operating at any continuous-duty point defined by the envelope of conditions specified in this Section. The method for calculating shaft deflection shall be as established in Section 43 23 03. Additionally, under no circumstances shall the distance from the lower bearing and the hub of the impeller exceed two times the diameter of the shaft. The documentation required under Section 43 23 03 shall be included as a submittal.

D. Bearings:
   1. Bearings shall be heavy-duty, oil lubricated or permanently greased lubricated anti-friction type double shielded and factory sealed. Bearings shall be designed for an L-10 rating life of at least 50,000 hours at any operating condition specified in this Section. Loads for radial bearing calculations shall be calculated in accordance with this Section. Bearings isolators in accordance with 43 23 03 are not required for submersible pumps.

E. Impeller:

1. Alternate 1: The impeller shall be dynamically balanced with a non-clogging design capable of passing solids, fibrous materials, coarse solids, and other matter found in normal water applications through to the discharge nozzle. Impellers for pumps with discharge nozzles 4 inches in diameter and greater shall be not less than two-vane design. Fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw that is threaded into the end of the shaft, or a slip fit onto the shaft and drive key and fastened to the shaft by an impeller nut having cover for protection from pumped fluid. A wearing ring system designed for abrasion resistance shall provide efficient sealing between the volute and impeller.
2. Alternate 2: The impeller shall be statically balanced, semi-open, multi- vane, back-swept, non-clog design. The impeller vane leading edges shall be mechanically self-cleaned upon each rotation as they pass across a spiral groove located on the volute suction which shall keep them clear of debris, maintaining an unobstructed leading edge. The impeller(s) vanes shall have screw-shaped leading edges capable of handling solids, fibrous materials, coarse solids and other matter. The screw shape of the impeller inlet shall provide an inducing effect for the handling of potable water treatment residual solids ladened water. Impellers shall be locked to the shaft and shall be coated with alkyd resin primer.

F. Mechanical Seals:

1. The pump shall be provided with a tandem double mechanical seal running in an oil reservoir, composed of two separate lapped face seals. The lower seal unit, between the pump and oil chamber, shall consist of one stationary and one positively driven, rotating tungsten-carbide or silicon-carbide ring, with each pair of rings held in contact by a separate spring. The upper seal unit, between the oil sump and the motor housing, shall consist of one stationary tungsten-carbide or silicon-carbide ring and one positively driven tungsten carbide, or silicon-carbide ring. Ceramic seals will not be acceptable. The seals shall require neither maintenance nor adjustment and shall be easily replaceable. Conventional double mechanical seals with a single or a double spring between the rotating faces, or that require constant differential pressure to effect sealing and are subject to opening and penetration by pumping forces, will not be acceptable. The pump shall be capable of continuous submergence without loss of watertight integrity to a depth of 65 feet. The mechanical seal shall accommodate the manufacturer's shaft deflection at the seal face and shaft angularity with a safety factor of 3.
2. Each pump shall be provided with a seal lubricant chamber for the shaft sealing system. The seal lubricant chamber shall be designed to assure that an air pocket is provided in the seal lubricant chamber, to absorb the expansion of the seal lubricant due to temperature variations. The drain and inspection plug with positive anti-leak seal shall be easily accessible from the outside.
3. Oil shall be ANSI/NSF/CAN 61/600 certified.

G. MOTOR:

1. The pump motor shall be a squirrel-cage induction, shell type design, housed in an air-filled or an oil-filled, watertight chamber, NEMA B type Inverter Duty with a service factor of 1.15 based upon nameplate rating. Oil shall be ANSI/NSF/CAN 61/600 certified.

2. Motor shall be rated for operation with VFD. The manufacturer shall furnish an unqualified warranty guaranteeing (full replacement at no cost to the City) the performance of the motors furnished under this project for a period of five years when operating under the specified conditions.
3. The stator winding and stator leads shall be insulated with moisture resistant Class H insulation, which shall be rated at a temperature of 180 degrees C. Motor shall be provided with thermal sensors to protect the motor from excessive heating. Thermal sensors shall be as specified in this Section. The temperature rise of the motor shall not be in excess of that specified in NEMA MG-1 for class B insulating materials when operating continuously under load.
4. Motors shall be Factory Mutual or UL listed in accordance with UL 674 and 1207 for Class I, Group D hazardous atmospheres.
5. The motor shall be designed for continuous duty in air and in 95 degree Fahrenheit water, capable of sustaining a minimum of 20 starts per hour when operated with variable frequency motor controllers.
6. The junction chamber, containing the terminal board, shall be hermetically sealed from the motor. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to a terminal board.

H. COOLING SYSTEM:
1. The cooling system may rely on radiation of excess heat energy to the fluid in the wet well or, alternatively, shall be provided a closed-circuit circulating system utilizing glycol or heat transfer oil, which shall in turn circulate to a heat exchanger incorporated into the cavity behind the pump impeller. It is specifically required that the cooling system be compatible with the contemplated control schedule, which may require that the motor case to be exposed continuously or intermittently.
2. The cooling jacket shall encircle the stator housing to provide cooling for the motor under all conditions (i.e., submerged or non- submerged).
3. The cooling system shall not employ the pumped fluid to directly cool the motor through water passageways incorporated into the motor shell.
4. The system shall be designed to prevent clogging by virtue of dimensions and configuration and shall be specifically configured to maintain motor temperatures within conservative limits.

I. Temperature Sensors:
1. The stator shall be equipped with three thermal sensors, embedded in the end coils of the stator winding (one sensor in each stator phase). These shall be wired to the specified motor protection relay for motor protection.

J. Moisture Detection:
1. Provide motors with a moisture detection system.
   a. A primary moisture detector shall be provided in the stator housing leakage chamber.
   b. A second moisture detector shall be located in the motor junction box or inspection chamber.
2. All moisture detectors shall be wired to the motor junction box for connection to the specified motor protection relay.

3. Moisture detectors shall be either mechanical float switch or capacitance probe type as recommended by the manufacturer.

K. Motor Protection Relay:
   1. Provide motor protection relay to protect motor from high temperature and moisture.
   2. During normal pump operation, the temperature switch shall be closed and the leakage switch shall be normally open. Sensor circuit shall operate on 12 or 24 VDC feed from the main relay body. The relay shall be provided with LEDs to indicate status of relay on face for leakage, temperature, and supply voltage.
   3. Latch detection of open temperature switch. An external reset shall be required to clear alarm. Retain relay state during power failures for temperature.
   4. Moisture detection shall auto reset.
   5. Power supply shall be 120 VAC.
   6. Provide one SPDT contact for remote over-temperature alarming. Provide one SPDT contact for remote moisture detection alarming.
   7. Relay shall be UL or UR approved, suited for panel installation.
   8. Relay shall be mounted inside the associated pump's motor controller panel. Mounting shall be DIN rail mount mount. Coordinate to provide relay for installation at the shop where the associated motor controller is being fabricated. Coordinate size, wiring, and mounting of the relay into the motor controller.
   9. Relay manufacturer shall be Xylem-Flygt, ATC Diversified Electronics, Dwyer, or approved substitute.

L. Variable Frequency Drives:
   1. The variable frequency drive will be provided by the Contractor conforming to the requirements of Section 26 29 23, the Contract electrical one-line diagrams, and the Contract wiring diagrams.

M. Cables:
   1. Cable:
      a. The pump shall have two cables. One cable shall be for power, and one cable shall be for control (the motor thermal sensors and moisture detector). The cable design shall be suitable for installation in a municipal water pumping station. The cable length shall not exceed the product manufacturer's recommended length. The Contractor shall be responsible for determining the length of cable required to wire the motors and sensors from the wet well to the terminal boxes. The Contractor shall provide additional cable length for slack to allow the pumps to be removed from the wet well. The length of cable for slack shall be based on the pump manufacturer's recommendation.

2. Cable Seal:
    a. The cable entry water seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall be comprised of individual cylindrical elastomer clamps having a close tolerance fit against the cable conductor insulation and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland, potting chamber or terminal board, which shall isolate the motor interior from foreign material gaining access through the pump top. If a potting chamber is used, the potting procedure shall employ an epoxy-potting compound combined with a procedure that insures penetration of the compound into the individual cable conductor strands to prevent development of wicking pathways for entrance of water into the motor.
3. Cable Disconnection:
    a. The pump shall be designed such that power/ control cable can be removed from the pump motor without breaking the cable seal. The power/ control cable shall be sealed to a removable motor chamber cap that shall be universally mateable to the same manufacturer's pump series. The pump shall be able to be removed from the wet well and disconnected from the cable by removing the motor chamber cap. A spare removable chamber cap with 15 feet of cable shall be provided.

N. TERMINAL BOXES: A terminal box shall be provided for each submersible pump. Cords from the pumps shall be connected to the terminal boxes with plugs. The contractor shall terminate submersible cables into plugs to mate up with receptacles located in the terminal boxes per this section.
1. Boxes, Plugs, and Receptacles:
    a. Class I, Division 1, Group D.
    b. Water tight.
    c. The receptacle/plug shells shall be machined from Stainless Steel type 316.
    d. See the drawings for information about boxes, conduits, and cords.
    e. Terminals per specification Section 26 05 33.
2. Pump terminal box:
    a. Contain a ground stud bonded to the enclosure and support four #8 AWG crimped one hole standard barrel terminal lugs.
    b. Box shall have two receptacles/plugs on the bottom. One receptacle/plug for motor power and one receptacle/plug for motor sensors.
3. Acceptable plug/receptacle manufacturers:
    a. Vantage Technologies
    b. Or approved substitute

O. NOT USED:

P. Pump Discharge Connection Seal:

1. The connection between the pump discharge connection shall be fitted with a means of sealing. The seal may be either a replaceable dynamic seal or a metal-to-metal seal to effect a complete closure between the pump discharge flange and the mating connection on the anchor fitting described in this Section. Leakage through the seal shall not exceed 1.5 percent of the flow specified for Condition Point A when operating at pump shutoff head and not more than 1 percent of total pump flow at Condition Point B. The seal shall be subject to field test for acceptance in accordance with the requirements of this Section.
2. The dynamic type of seal shall affect a seal meeting the requirements of this paragraph using the head developed by the pump when in operation to expand the sealing device, which may be of metallic or elastomeric construction, against the inner contours of the discharge fitting. The design of the seal shall incorporate features to protect the integrity of the seal during the pump removal/setting process.

Q. Pump Anchorage, Guide System and Access Cover:

1. The pump shall be provided with a guide system to allow easy removal of the pump without entering the wet well. The guide rail system may be of either the single or dual rail type. The discharge connection shall be bolted to the structure as indicated and shall serve as a lower attachment for the guide rails. The discharge connection shall be either horizontal or elbow discharge type, as indicated. The anchorage system shall be designed to transmit the forces specified in this Section safely to the structure. Calculations and supporting documentation justifying the support design shall be provided with the submittals required under Section 43 23 03.
2. The pump and guide rail system shall be designed to automatically connect the pump to the discharge piping when lowered into place on the discharge connection. The design shall be non-sparking and shall conform to UL requirements for installation in a location classified in accordance with NFPA 70, Article 500 for Class 1, Group D, Division 1 locations. The pump shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose, and no need for personnel to enter the pump wet well or sump. Sealing of the pumping unit to the discharge connection shall be accomplished by a simple linear downward motion of the pump with the entire weight of the pumping unit guided to and pressing tightly against the discharge connections. No portion of the pump shall bear directly on the floor of the sump and no rotary motion of the pump shall be required for sealing. Guide bars provided for directing the pump into position or for removing the pump for maintenance shall steer the pump into proper contact with the discharge elbow. Once the pump has been positioned on its support fitting at the discharge fitting, the guide bar system shall not be required for pump support.
3. Access frames and covers furnished by the Contractor shall be as specified in Section 08 31 20 and as shown on drawings. Hardware and miscellaneous attachments shall all be constructed out of ASTM A276, Type 316 stainless steel. Dielectric isolation shall be provided for dissimilar metals.

R. Accessories
   1. Pumps shall be provided with lifting chains, guide bars, upper guide bar brackets, intermediate guide bar brackets, cable holder assemblies, safety chain hook assemblies, discharge elbow connections, metric to english pipe increaser, anchor bolts, and all other accessories necessary to complete the installation as specified. All connecting hardware and miscellaneous attachments shall be constructed out of ASTM A276, Type 316 stainless steel. Dielectric isolation shall be provided for dissimilar metals.

2.07 EQUIPMENT AND SYSTEM CONTROLS

A. Section 40 61 13 specifies control system requirements. (I&C: May want to include process control narrative here.)

2.08 FINISHES

A. Procedures: Section 09 90 00

B. Prime Coat: Shop applied, manufacturer's standard coating system.

C. Finish Coat: Shop applied, manufacturer's standard coating system.

2.09 SOURCE QUALITY CONTROL

A. Provide non-witnessed factory testing at a location in the Continental United States and in accordance with Section 43 23 03-1.06

B. Submit factory testing results report in accordance with Section 43 23 03.

C. Hydrostatic tests:
   1. Factory-test all pressure-sustaining parts in accordance with Section 43 23 03.

D. Performance and NPSH tests:
   1. Subject each pump to performance and NPSH testing in accordance with Section 43 23 03 to verify the full range of operating condition

E. Motor tests:
   1. First check impeller, motor rating, and electrical connections for compliance with the specifications
   2. Subject all motor circuits to electrical resistance tests to confirm functionality

PART 3 EXECUTION

3.01 EQUIPMENT MOUNTING

A. Procedure: Section 43 05 13

B. Position equipment pad and equipment anchors for final placement of equipment

C. Use a bolting template to position equipment anchors

D. Level mounting plates

E. Pour grout bed supporting each mounting plate

F. Eliminate grout voids below mounting plate

G. Tension equipment anchors

H. Provide a completed Form 43 05 13-A, Section 01 99 90, for each equipment installation

3.02 FIELD QUALITY CONTROL

A. Field Testing
   1. Procedures: Section 01 45 00 and Section 01 91 00.
   2. Vibration Test:
      a. Vibration levels shall be determined by affixing suitable sensors to the top of the motor housing in both the x-x (parallel to the nozzle) and y-y (perpendicular to the nozzle) directions. The Contractor or his designated testing agent shall provide all sensors and monitoring equipment.
      b. As a condition precedent to final acceptance of the equipment, the pumps shall be individually operated at all specified operating conditions. The Contractor shall provide the means to recirculate pumped fluid or alternatively throttle the pumps to achieve the specified head at specified flow.
      c. Vibration levels shall not exceed that specified in paragraph 1.07 when the pump is operating within the manufacturer's listed POR as determined in accordance with Section 43 23 03. When operating at conditions outside the POR, vibration levels shall be no more than 125 percent of that specified in paragraph 1.07.
   3. Leakage Test:

      Leakage testing for each wet-pit pumps shall include five sets of tests, each set consisting of two tests, one with the pump operating against a closed discharge valve and one with the pump operating at Condition B, as specified in paragraph 2.03. Testing shall be scheduled with and witnessed by the Construction Manager. For each test the wet well shall be drawn down such that the pump discharge elbow is clearly visible prior to the test. Additional lighting shall be provided if necessary to clearly see leakage discharge, if any, from the discharge elbow connection. Each test shall be not less than 30 seconds in duration. Between each test set, the pump shall be lifted clear of its support bracket and re-lowered to connect again. The tests results shall be video recorded. The apparent average rate of leakage shall not exceed that specified in paragraph 2.06 Pump Discharge Connection Seal. If the discharge connection leakage rate at either against a closed valve or at Condition Point B exceeds the specified allowance, the Contractor shall cause the pump manufacturer to correct the defect and the pump shall be tested again as described in this paragraph. If the pump should fail the second test, the pump shall be removed from the site and the Contractor shall furnish a replacement which in turn shall be tested for acceptance in accordance with this paragraph. Video files shall be submitted.

B. Manufacturer Services:
   1. Procedures: Section 01 45 23 and Section 01 91 00.

2. On-Site Inspections and Training: Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
    a. Installation Inspections: Assist, supervise, and inspect the Contractor's activities during installation. Provide 6 inspection hours. Provide a completed Form 43 05 11-A, Section 01 99 90.
    b. Component Test Phase Inspections: Assist, supervise, and inspect the Contractor's activities during the system test phase specified in Section 01 91 00 and this Section. Provide 8 inspection hours.
    c. Training Sessions: Procedures Section 01 79 00. Provide a minimum of [8] hours classroom training for each training session. Conduct [two] training sessions, [one] training session per week on [two] consecutive weeks to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 43 05 11-B, Section 01 99 90.

3.03 SYSTEMS START UP

A. Procedures: Section 01 45 00.

B. Preoperational (factory) testing; See paragraph 2.09.

C. Component testing: Perform the following tests.
    1. During initial pump installation, verify on one pump that the davit crane has the clearance and capacity to lift out the pump on rail system to accommodate routine pump maintenance.
    2. Complete field testing in accordance with paragraph 3.02.

END OF SECTION

SECTION 43 23 92

MULTI-STAGE VERTICAL CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies vertical multi-stage, constant speed, end suction, centrifugal pumps for [flash mixing].
   1. Each pumping unit shall be complete with pump, drive unit, variable speed drive, base, and all appurtenances to provide a complete pumping system.
   2. Except as specifically referenced in this section, Section 43 23 03 provisions will not apply to equipment furnished under this section.

B. Equipment List

Item	Equipment Number
Flash Mix Pump 1	20-P-10010
Flash Mix Pump 2	20-P-20010

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections not specifically listed below may apply.
   1. Section 26 29 23: Variable Frequency Motor Controllers
   2. Section 43 05 11: General Requirements for Equipment
   3. Section 43 05 17: Vibration and Critical Speed Limitations
   4. Section 43 05 21: Common Motor Requirements for Equipment

1.03 REFERENCES

A. References
   1. This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. If requirements of this section conflict with those of the listed documents, requirements of this section prevail.
   2. Unless otherwise specified, reference documents refer to documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if no Bids). If referenced documents have been discontinued by the issuing organization, refer to replacement documents issued or otherwise identified by that organization. If there are no replacement documents, refer to the last version of the document before it was discontinued. Where document dates are given in the following listing, those documents refer to the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings

Reference	Title
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
ASTMA A48	Gray Iron Castings
ASTM A108	Steel Bars, Carbon, Cold Finished, Standard Quality
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A278	Gray Iron Castings for Pressure Containing Parts for Temperatures of up to 650 Degrees F
ASTM A322	Steel Bars, Alloy, Standard Grades
ASTM A576	Steel Bars, Carbon, Hot Wrought, Special Quality
ASTM A743/A743M	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistance for General Application
Hydraulic Institute Standards	Latest Standards of the Hydraulic Institute

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment pad: concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.
   2. Mounting pads: thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility
   1. Assign unit responsibility, as specified in Section 43 05 11, to the pump manufacturer for the pumps and motors as specified in this section and Section 43 05 21 and the variable speed drive equipment specified in Section 26 29 23.
   2. Provide a completed and signed Unit Responsibility Certification Form (Form 43 05 11-C, Section 01 99 90).

1.06 SUBMITTALS

A. Action Submittals
   1. Comply with procedures described in Section 01 33 00:
      a. Submit a copy of this specification section (with addendum updates included) and all referenced and applicable sections (with addendum updates included).
         1) Mark each paragraph with a check-mark (✓) to indicate specification compliance or mark to indicate requested deviations from specification requirements.
         2) Use check-marks (✓) to denote full compliance with a paragraph as a whole.
         3) If deviations from the specifications are indicated, underline and denote each deviation with a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations.

4) Remaining portions of the paragraph not underlined signify the Contractor's compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

b. Submit a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment. Include addendum updates applying to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings with *"no changes required"*. Failure to include copies of relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

c. Show predicted pump performance curves. Show head, capacity, speed, power, efficiency, and net positive suction head (NPSH) required on the ordinate plotted against capacity on the abscissa.

d. Provide motor submittal information as specified in paragraph 43 05 21-1.03.

e. Provide drawings showing general dimensions and confirming pump piping connections, with construction details including dimensions and materials of construction, and wiring diagrams.

f. Provide manufacturer's catalog data, showing materials of construction and including a list of spare parts to be provided.

B. Informational Submittals

1. Comply with procedures described in Section 01 33 00:
   a. Show guaranteed pump performance curves.
   b. Provide applicable operation and maintenance information as specified in Section 01 78 23.
   c. Provide certification that pumping units meet vibration and critical speed limitations as specified in Section 43 05 17.
   d. Submit Installation Certification Form 43 05 11-A as specified in paragraph 43 23 92-3.01.
   e. Provide motor product data as specified in paragraph 43 05 21-2.05.
   f. Submit Training Certification Form 43 05 11-B as specified in paragraph 43 23 92-3.03.

C. Closeout Submittals

1. Comply with procedures described in Section 01 78 23.
   a. Provide field vibration test reports in accordance with paragraph 43 23 03-3.06.
   b. Provide operating and maintenance submittals as specified in Section 01 78 23.
   c. Submit Installation Certification Form 43 05 11-A as specified in paragraph 43 23 88.13-3.01.
   d. Submit Training Certification Form 43 05 11-B as specified in paragraph 43 23 88.13-3.02.

e. Spare Parts
    1) The following spare parts shall be provided if one pump is furnished under this section. If more than one pump is furnished, the following shall be provided for each pair of pumps. Spare parts shall be tagged and stored as specified in paragraph 43 05 11-2.12.
        a) Three sets of all gaskets
        b) One set of pump bearings
        c) One set of wearing rings
        d) One set of seals, including shaft seal

1.07 QUALITY ASSURANCE

A. Certifications
    1. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001.
    2. Application for certification under ISO 9001 is not an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and notarized.

B. Critical Speeds
    1. Critical speeds shall be in accordance with Section 43 23 03-1.04 except when the title of the detailed section includes "Custom Engineered" in which case Section 43 23 03-1.05 applies.

C. Vibration Limits
    1. Vibration limits shall be in accordance with Section 43 23 03-3.06 and subject to field testing in accordance with paragraph 3.04 of this section.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products satisfying the requirements of this section. The manufacturer's standard product may require modification to conform to specified requirements.
    1. Grundfos
    2. Aurora
    3. Taco
    4. Approved equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions
    1. The pump shall be designed to pump raw water from city creek that has been screen upstream by a coanda screen.
    2. The fluid to be pumped is anticipated to range between 2 degrees C and 35 degrees C and may be expected to contain small amounts of grit and other particulates.
    3. The pumps will be operated at a variable speed.

B. Operating Conditions

1. The pump shall perform in accordance with the following:

Full Speed Operation	
Condition A [a,e]	
Capacity, gpm	250
Total head, feet	139
NPSHA, feet	16
Condition B [b,e]	
Capacity, mgd	from pump H/Q curve
Total head, feet	130
NPSHA, feet	16
Reduced Speed Operation	
Condition C [c,e]	
Capacity, mgd	139
Total head, feet	30
Pump speed	Reduced
NPSHA, feet	17
Condition D [d,e]	
Capacity, mgd	TBD
Total head, feet	TBD
Pump speed	Minimum
NPSHA, feet	TBD

a. *Take Condition A as the rated operating condition. Guarantee performance at the rated condition in accordance with Section 43 23 03. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Select pumps furnished under this section to achieve Condition A performance, and also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and published in the manufacturer's published application data for the specific model proposed for this application.*

b. *Condition B head is presented to indicate operating conditions when the pump is operating at maximum speed against minimum anticipated system head, assuming a hypothetical head-capacity curve. Use Condition B for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ, and shall not be less than 10 percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected. Net positive suction head available (NPSHA), as listed for Condition B is calculated on a pumped flow of 230 gpm.*

c. *Condition C is the anticipated continuous duty minimum speed condition. Provide pumps furnished under this specification capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 43 23 03. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3, and list in the manufacturer's published application data for the specific model proposed for this application.*

d. *Condition D represents the expected momentary (startup/shutdown) condition. Pumps furnished under this specification will operate for no more than 30 seconds at this condition when initiating or terminating a service cycle. The maximum anticipated number of service cycles is 12 per day.*

e. Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1–1.6. NPSHA in the above tabulation is referred to the pump inlet piping at centerline elevation as shown and is calculated in accordance with ANSI/HI 1.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. An allowance of 5 feet has been included for the presence of volatile constituents in the pumped fluid. Required NPSHA margin shall be as specified in Section 43 23 03.

C. Design Requirements

1. The pump shall be designed to operate without damaging cavitation, and the motor and pump combination shall operate without vibration over the specified range of conditions. The pump head capacity curve shall slope in one continuous curve with no point of reverse slope inflection.
2. All components shall be designed to safely withstand forces resulting from flow reversals, up to 125 percent of maximum speed, within the pump during shutdowns caused by power failure.
3. The complete pumping unit shall be designed to operate without overload on any component at any point along the pump's entire operating curve without using the motor's service factor.
4. Equipment furnished under this section shall conform to the following characteristics:

Pump	**Equipment No.**
Minimum sphere, inches diameter, capable of passing through the pump from inlet to discharge	1 mm
Efficiency at Condition A, minimum, percent [a]	TBD
Piping connection size, inches, minimum	
Inlet	4"
Discharge	4"
Motor	
Horsepower	15 hp
Type (See Section 43 05 21)	TEFC – (Corrosion) Severe Duty, Enclosed]
Inverter duty	Yes
Space heater	Yes
Thermal protection	Yes
Ambient duty rating	+40 C
Operating speed, rpm, maximum	TBD
Voltage rating	460 volt, 3 Phase
Reversing motor	No
Multispeed motor	No
Motor starting type	VFD
Voltage rating	460 volt, 3 Phase

Notes:

a. Because the pumps are to operate at constant speed, the pump shall be selected so that the rated condition lies within 5 percent (based upon capacity) of the best efficiency point (BEP) on the pump's head-capacity curve.

b. The motor shall be nonoverloading within the selection criteria set forth in Section 43 05 21. Pump selections which do not conform to this requirement without requiring a motor with a nameplate rating greater than that listed are not acceptable.

D. Vibration and Critical Speeds
   1. The pump shall comply with the requirements of Section 43 05 17.

2.03 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Suction/discharge base, pump head, flanges and couplings	316 Stainless Steel
Motor stool	TBD
Shaft	Stainless steel, Type 316
Impellers 1	316 Stainless Steel
Wearing rings	Teflon or Equal
Intermediate bearings	Aluminum Oxide Ceramic or Graflon
Bottom bearing rings, shaft journal	Tungsten carbide, replaceable
Cartridge shaft seal	Per manufacturer, corrosion resistant, replaceable without disassembling pump (EPDM [std], Viton, or Buna O-rings)
Motor seal	Per manufacturer, replaceable without removing motor

Notes:

a. Impellers shall be balanced at the factory. Balancing of the impeller in the field is not permitted.

b. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials to provide greater strength or meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Variable Frequency Drive:
   1. The variable frequency drive shall conform to the requirements of Section 26 29 23.

2.04 EQUIPMENT MOUNTS

A. Mounting Plates
   1. Use [Fabricated Steel Frame, Baseplate, Plate Steel Soleplate, Polymer Concrete Soleplate, or Corrosion Resistant FRP Baseplate].
   2. Install mounting plates per Section 43 05 13.
   3. Mount plate leveled to TBD inch/foot or less.
   4. Mount pump and motor on a common baseplate. Baseplate collects, contains, and directs seal water leakage to a single outlet.

B. Grout Type
   1. Use Epoxy Grout or Cementitious Non-Shrink Grout per Section 03 60 00.

C. Equipment Anchors
   1. Install per Standard Detail D01002.

D. Equipment Anchor Sleeves
   1. Install per Section 43 05 13.
   2. Length shall not be less than 15D (D = nominal bolt diameter; bolt diameter determined by mounting plate manufacturer).

E. Equipment Pad
   1. Install per Standard Detail D01007

2.05 SOURCE QUALITY CONTROL

A. Factory Tests
   1. Factory tests are not be required. However, the manufacturer shall guarantee the performance specified under paragraph 2.02 Operating Conditions, Condition A.

PART 3 EXECUTION

3.01 INSTALLATION

A. Each pumping unit shall be aligned, connected, and installed in accordance with the manufacturer's recommendations.

B. The installation shall be certified on Form 43 05 11-A as specified in Section 01 99 90.

3.02 FIELD QUALITY CONTROL

A. After completion of installation, each pumping unit shall be field tested to demonstrate compliance with the performance requirements as specified.
   1. A minimum of 4 hours of training shall be provided by the pump manufacturer’s service representative.
   2. Training shall conform to Section 01 79 00.
   3. Certify completion of training on Form 43 05 11-B as specified in Section 01 99 90.

END OF SECTION

SECTION 43 41 43.13

HIGH DENSITY CROSSLINKED POLYETHYLENE TANKS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies crosslinked high-density polyethylene tanks for chemical storage.

B. Type:

1. Unless otherwise specified, tanks shall be circular cross-section, vertical, complete with piping outlets, drains, overflows, and anchoring system. Covered tanks shall be vented, and where specified, tanks shall be provided with entrance manways, level indicators, electrical heat tracing, spray-on urethane foam insulation, and exterior coating.

C. Equipment List:

Item	Equipment No.
PEA BATCH DAY TANK	84-T-00020
SODIUM HYPOCHLORITE DAY TANK 1	89-T-00010
SODIUM HYPOCHLORITE DAY TANK 2	89-T-00020

D. Design Requirements:

1. Physical Characteristics: Chemical storage tanks provided under this section shall have the following characteristics:

Equipment number[1,2]	84-T-00020	89-T-00010	89-T-00020
Type[3]	CB	CD	CD
Nominal diameter, ft	4	4	4
Nominal height,[4] ft	6.25	7	7
Liquid depth, ft	9	5	5
Nominal capacity, gallons	335	545	545
Manway:[5]	N/A	Yes	Yes
• Mounting[6]	N/A	TM	TM
• Diameter, inches	N/A	17	17
• Exposure	Inside	Inside	Inside
Color	White	White	White

Notes:

1. *All Tanks shall be provided with level indicator.*
2. *Tanks shall not use molded flange full drain fittings. (IMFO)*
3. *CD = closed, domed top; CB = closed, cone bottom; CF = closed, flat top; OIF = open, internal flange; OEF = open, external flange; FLR = flat lid removable; FLH = flat lid hinged.*
4. *Nominal height of domed top tanks is the dimension measured along the straight cylindrical portion of the tank and does not include the rounded end.*
5. *Unless otherwise specified, manways shall be integrally molded with the tank.*
6. *TM = top mount; TSM = top and side mount.*

2. Operating Conditions: Chemical storage tanks provided under this section shall be suitable for the following operating conditions:

Equipment number	84-T-00020	89-T-00010	89-T-00020
Chemical stored	Anionic Polymer	Sodium Hypochlorite	Sodium Hypochlorite
Concentration, percent	100	5.37	5.37
Unit weight, lb/gal	9.17	0.48	0.48
Design specific gravity	1.10	1.08	1.08
Solution pH	TBD	11	11
Solution viscosity, centipoise at 20 deg. F	500-	TBD	TBD
Maximum fluid temperature, deg. F	100	TBD	TBD
Minimum fluid temperature, deg. F	7	TBD	TBD
Minimum ambient air temperature, deg. F	TBD	TBD	TBD

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM C177	Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
ASTM D638	Tensile Properties of Plastics
ASTM D746	Brittleness Temperature of Plastics and Elastomers by Impact
ASTM C273	Shear Properties in Flatwise Plane of Flat Sandwich Constructions or Sandwich Cores
ASTM D1505	Density of Plastics by the Density Gradient Technique
ASTM D1525	Vicat Softening Temperature of Plastics
ASTM D1621	Compressive Properties of Rigid Cellular Plastics
ASTM D1622	Apparent Density of Rigid Cellular Plastics
ASTM D1623	Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics
ASTM D1693	Environmental Stress-Cracking of Ethylene Plastics
ASTM D2126	Response of Rigid Cellular Plastics to Thermal and Humid Aging
ASTM D2842	Water absorption of Rigid Cellular Plastics
ASTM D2856	Open Cell Content of Rigid Cellular Plastics by the Air Pycnometer
ASTM E84	Surface Burning Characteristics of Building Materials
NEMA ICS 6	Enclosures for Industrial Control and Systems
Phillips Chemical Technical Bulletin SSL-193	Impact and Gel Testing
UBC	Uniform Building Code

B. Factory Test:
   1. Following fabrication the tanks, including factory applied pipe outlet fittings, shall be hydraulically tested with water. Test methods may include adding a 2.5 psig air pad to filled tanks or filling the tanks with standpipes, raising the maximum water surface approximately 6 feet higher than the normal maximum tank level. The test duration shall be 24 hours with proof of acceptance being an affidavit signed by the factory inspector. Following successful testing, the tank shall be emptied and dried prior to shipment.

C. Manufacturer's Warranty:
   1. The tank shall be warranted for 7 years to be free of defects in material and workmanship. Warranty shall be prorated over the last 5 years.

D. Manufacturer's Experience:
   1. The tank manufacturer shall have a record of at least ten installations during the previous 5 years for the tank sizes specified. The manufacturer must be capable of providing names of users and specific locations which can be visibly inspected.

E. Unit Responsibility:
   1. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the tank manufacturer for all equipment specified in this section.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   3. Tank manufacturer's data and dimensions showing locations of all openings, location of level sensors, seismic support structure and anchoring system details, and location of tank accessories.
   4. Details on outlet fittings, flexible connections, and vent and level indicator.

5. Manufacturer's experience required in paragraph 1.02 Manufacturer's Experience.
6. Electrical heat tracing installation details, sizing calculations, wattage–amperage (120 volt) and thermostat details.
7. Insulation data, name of insulation contractor, and insulation contractor credentials.

1.04 ENVIRONMENTAL CONDITIONS

A. The bulk storage tanks shall be suitable for indoor installation.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. The tanks specified in this section shall be manufactured by Poly Cal Plastics, Inc., Poly Processing, Nalgene, or equal, modified to provide the specified features.

2.02 TANKS

A. The tanks provided under this specification shall be constructed of high-density crosslinked polyethylene using a rotationally molded fabrication process. Resin used in the tank shall be equal to Phillips Chemical crosslinked polyethylene Marlex CL 200 or equal and shall contain 1/2 to 1 percent ultraviolet stabilizer. Where black tanks are specified, the black resin shall contain 3 percent carbon black blended into the resin. The tank material shall meet or exceed the following test properties:

ASTM Test	Parameter	Value
ASTM D1505	Density, gms/cc	0.930-0.933
ASTM D1693	Environmental stress cracking, F50, hrs	>1,000
ASTM D638	Tensile strength, ultimate, psi, 2-inch minimum	2,600
ASTM D638	Elongation at break, percent, 2-inch minimum	450
ASTM D746	Brittleness temperature, degrees F	<-180
ASTM D1525	Vicat softening point, degrees F	255
Phillips SSL-193	Impact resistance at -40 degrees F, ft/lb	>120
Phillips SSL-193	Percent gel, innermost 1/32 inch of inner wall	>65
--	Percent gel, outermost 1/32 inch of outer wall	>90
--	Percent gel, entire wall thickness	>80

B. Wall thickness of the tank shall be designed by the manufacturer with a hoop stress no greater than 500 psi and a safety factor of no less than 2 using the Barlow formula. Calculations shall be based on design specific gravity specified in paragraph 1.01 Operating Conditions.

C. The tank manufacturer shall provide a certificate attesting that the tank materials meet or exceed the test properties specified above. Such certificates shall be signed by an officer of the manufacturer's corporation and shall be notarized.

2.03 TANK FITTINGS

A. Tank fittings shall be according to the fitting schedule below. Gasket material shall be closed cell, crosslinked polyethylene material equal to the material specified in paragraph 2.02. PVC fittings shall be compression type Schedule 80 long shank high-torque design with minimum of 85 percent threaded contact. No metals shall be exposed to tank contents.

Equipment No.	Fitting type[1]		
	84-T-00020	89-T-00010	89-T-00020
1. Fill line	DB-H	DB-H	DB-H
2. Overflow	DB-H	DB-H	DB-H
3. Tank drain	DB-H	DB-H	DB-H
4. Vent	PVC	PVC	PVC
5. Outlet to pump	DB-H	DB-H	DB-H
6. Pipe supports	PVC	PVC	PVC

Notes

[1]Refer to drawings for fitting size and location. Legend for abbreviations:

DB-H: Double bolt with Hastelloy-C studs and polyethylene encapsulated heads.

DB-SS: Double bolt with 316 SS studs and polyethylene encapsulated heads.

IMFO: Integrally molded flange.

PVC: Double-nut PVC fitting.

2.04 LEVEL INDICATORS

A. Level indicators shall be provided for tanks 84-T-00020, 89-T-00010 and 89-T-00020. Graduations shall be provided at every 200-gallon interval with 1,000-gallon intervals clearly labeled for bulk storage tanks. Unless otherwise specified, graduations shall be marked on the tank exterior. The level indicator shall be completely assembled to the tank and shall consist of PVC float, indicator, polypropylene rope, perforated interior pipe, PVC roller guides, clear sun and chemical resistant sight tube, and necessary pipe supports. The level indicator shall act inversely to the tank contents and shall not allow entrance of tank contents into the sight tube at any time.

2.05 TANK INSULATION – NOT USED

2.06 HEAT TRACING – NOT USED

2.07 SEISMIC RESTRAINT SYSTEM

A. The tanks shall be provided with seismic restraint systems manufactured in conformance with plans and instructions prepared and stamped by a registered structural engineer in the State of Utah. The lateral restraint assembly shall be designed for the seismic loads in Section 01 73 24, Design Requirements For Non-Structural Components and Non-Building Structures.

2.08 SAFETY SIGNS

A. Each tank inlet and tank outlet shall be clearly marked with hazardous material warning signs, 10 inches by 14 inches in size. Each sign shall have the words "DANGER" and 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"). Signs shall comply with Section 10 14 00, modified as specified herein.

2.09 FLEXIBLE CONNECTION

A. Tank connections shall include a flexible spool type flanged connector. Spool casing and liner must be suitable for chemical involved.

2.10 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Applicable operation and maintenance information as specified in Section 01 78 23.
   2. Signed affidavit by the tank manufacturer indicating that the tank was successfully factory tested as specified in paragraph 1.02 Factory Test.
   3. Copy of manufacturer's warranty specified in paragraph 1.02 Manufacturer's Warranty.
   4. Certification of tank material test data as specified in paragraph 2.02.
   5. Manufacturer's recommendations for installation.
   6. Seismic restraint plans and instructions specified in paragraph 2.07.
   7. Installation Certification Section 43 05 11-Form A specified in paragraph 3.01 Tanks.
   8. A complete set of structural calculations shall be provided for the tank structure, including certifications by the tank Manufacturer that the tanks conform to seismic zone design requirements. All such submissions shall be stamped by a Registered Professional Engineer licensed in Utah.

PART 3 EXECUTION

3.01 INSTALLATION

A. Tanks:
   1. The tanks shall be installed as specified and in accordance with the manufacturer's written instructions. Prior to being placed in service, tank installations shall be checked by a factory-trained representative of the manufacturer, who shall fill out and submit the Installation Certificate Form 43 05 11-A specified in Section 01 99 90.

B. Tank Insulation:
   1. Tank insulation shall be applied only by the tank manufacturer. Proper adhesion of the foam to all surfaces shall be the responsibility of the manufacturer. The final foam surface shall be free from bumps, rings, pinholes, voids, and depressions. Mating surfaces of piping flange connections and other items noted by the Construction Manager shall be kept clear of insulation.

3.02 FIELD TESTING

A. Field testing shall be in accordance with requirements in Section 01 45 20 and as specified herein. Each tank shall be field tested by filling entire contents with water and monitoring the tank as well as all fitting connections for at least 24 hours. Any leaks shall be corrected by the manufacturer's representative prior to acceptance. Following successful field tank testing, the tank shall be completely emptied and dried.

3.03 SAFETY

A. Appropriate sections of the safety precautions outlined by Cellular Plastics Division of the SPI, the NFPA, OSHA, and the material manufacturers shall be followed. All personnel shall be familiar with the hazards involved in the use of equipment and materials on the project and the proper techniques and procedures to safely handle and apply the materials.

END OF SECTION

SECTION 46 07 10

CHEMICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the supply, installation, testing, and commissioning of chemical systems. The chemical systems shall be suitable for storage, metering, and injection of the respective chemicals.

B. The following chemical systems are covered by this specification:
   1. Sodium hypochlorite systems
      a. SH Transfer Pump
      b. SH RAW Water Pipe Feed
      c. SH Filter Inlet Channel Feed
      d. SH Combined Filter Outlet Pipe Feed
      e. SH Backwash Pipe Feed

C. Limitations: The chemiacal storage tanks, equipment, pump skids, and other accessories of the chemical systems shall be suitable for installation within the space allocated for each system. Where systems are delineated herein to be the responsibility of a particular Subcontractor/Supplier, that Subcontractor/Supplier is responsible for confirming design criteria, selection, and arrangement of appurtenances such that the system functions as needed to support the process equipment provided by the Subcontractor/Supplier.

1.02 REFERENCES

A. Comply with applicable provisions and recommendations of the latest edition of the following, except as otherwise shown or specified:

Reference	Title
AWWA B300	Hypochlorites
ASME A13.1	Scheme for the Identification of Piping Systems
ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard
ASTM D1785	Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D3299	Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM D5421	Contact Molded "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
ASTM F441/441M	Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
HI 7.1 to 7.5	Controlled Volume Metering Pumps
HI 9.1 to 9.5	Pumps - General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation

1.03 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below (all applicable Division 1 specifications are applicable).
   1. Section 01 66 00 – Product Storage Handling Requirements
   2. Section 01 33 00 – Submittal Procedures
   3. Section 01 45 20 – Equipment and System Performance and Operational Testing
   4. Section 01 78 23 – Operation and Maintenace Data
   5. Section 01 73 24 - Design Requirements for Nonstructural Components and Nonbuilding Structures
   6. Section 0111 80 – Environmental Conditions
   7. Section 43 05 11 General Requirements for Equipment
   8. Section 43 05 21 Motors
   9. Section 05 05 20 Anchor Bolts
   10. Section 40 05 31 Thermoplastic Process Pipe
   11. Section 40 05 31.19 CPVC Double Containment
   12. Section 40 05 63.06 Ball Valves – CPVC
   13. Section 40 73 00 Pressure, Strain and Force Measurement
   14. Section 46 33 33 Magnetic Drive Gear Pumps for Chemical Service
   15. Section 46 33 44 Peristaltic Metering Pumps
   16. Section 46 41 17 Inline Static Mixers and Injectors
   17. Section 40 05 72.82 Degassing Valve, CPVC

1.04 UNIT RESPONSIBILITY:

A. The Subcontractor/Supplier(s) of the Packaged Chemical Systems provided under this section shall assume unit responsibility, as specified in section 43 05 11. This supplier has unit responsibility for both the equipment assembly specified in this section and all other equipment assembly components specified elsewhere but referenced in this section. A completed, signed certificate of unit responsibility (Section 01 99 90-form 43 05 11-C) shall be provided.

1.05 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00.
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Subcontractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph. The ENGINEER OF RECORD shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Provide a detailed, written justification for each deviation.

B. A copy of the contract document process and instrumentation drawings (P&ID) relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal.

   If no changes are required, the drawing or drawings shall be marked “no changes required.”

C. Shop Drawings:
   1. Illustration, specification, and engineering data on all components of the system.
   2. Drawings showing assembly, accessories, and installation details.
   3. Setting drawings, templates, and direction for the installation of anchor bolts and other anchorages.
   4. Deviations from Contract Documents.
   5. Drawings and design calculations, as applicable.

D. Calculations:
   1. The pump skid supplier shall submit structural calculations (including anchorage) for the pump skid sealed and signed by an Utah registered Professional Engineer.

E. The chemical system supplier shall submit a certificate of compatibility for all materials that will come in contact with the chemicals being handled.

F. Provide report on all shop testing performed prior to shipment.

G. Field Test Results:
   1. Written report giving the results of the field tests required herein or as part of the installation and start-up.

H. Certifications:
   1. Supplier’s Instructions Certification Form 43 05 11-A.
   2. Supplier’s Installation Certification Form 43 05 11-B.

I. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals, maintenance data and schedule, descriptions of operations, and spare parts information in accordance with Section 01 78 23.

J. Installation Procedures:
   1. General installation procedures. Include weights of all major assemblies and sub-assemblies.

1.06 QUALITY CONTROL

A. Subcontractor/Supplier's Qualifications:
   1. The suppliers shall be qualified and experienced in the design, construction, installation, and operation of equipment for the purpose required and shall regularly produce such systems. Subcontractor shall have experience in the production of substantially similar equipment and shall show evidence of satisfactory operation in at least five installations.

1.07 SHIPMENT AND STORAGE

A. The equipment shall be protected during shipment as specified in Section 01 66 00.

B. Ship equipment, material, and spare parts (where specified or required) complete except where partial disassembly is required by transportation regulations or for protection of components.

C. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

D. Provide short-term and long-term storage requirements to the Contractor.

1.08 ENVIRONMENTAL CONDITIONS

A. The units specified in this section shall be designed for installation under a canopy. Environmental conditions will be as described in Section 01 11 80.

PART 2 PRODUCTS

2.01 GENERAL CONFIGURATION

A. General:
   1. Each of the chemical systems will consist of the following:
      a. Fill lines from chemical transfer pump(s) to the day storage tanks(s) or tote(s)
      b. Day storage tank(s)
      c. Metering pump skids
      d. Chemical injectors
      e. All piping, valves, instruments, and other accessories such as pressure relief valves, back pressure valves, calibration columns, pressure gauges, and pressure switches.
      f. Storage tanks and metering pumps are specified separately and referenced herein. The metering pumps complete with the interconnecting piping, valves, instruments, and accessories shall be supplied as a complete skid as shown on the Drawings for each chemical system.

B. Metering Pump Skid Requirements:

1. Provide single, duplex, or triplex pump systems for the systems described below. Each system shall be constructed of lightweight, permanently welded 6060 T6 aluminum with acidic liquid iron phosphate three stage clean and coat pre-treatment and exterior grade corrosion resistant polyester polyurethane powder coat. Alternately skids may be fabricated of HDPE or FRP structural and molded shapes.
2. Each skid shall have the dimensions to provide access to each metering pump and specified accessories on each skid.
3. The skids shall be mechanically and electrically complete, requiring only the connection of electrical power, signal wiring, and inlet and outlet process chemical connections.
4. There shall be two side walls, a pump mounting base, and two rear back plates. Each of the two side walls shall be provided with nine service access cutouts and two accessory mounting slots.
5. Four 316 stainless steel skid mounting pads shall be provided which can be positioned to enable either floor mounting or wall mounting the skid. Each mounting pad shall be secured to two mounting holes in the skid structure by 18-8 stainless steel hardware.
6. Two 316 stainless steel pump mounting brackets with four mounting slots shall be provided. Pump mounting brackets shall be secured to the skid structure by 18-8 stainless steel hardware.
7. Custom engineered universal mounting brackets shall secure each of the valves to the skid structure. Valve mounting brackets shall be PVC. Valve mounting brackets shall be secured to pre-cut slots in the skid structure by 18-8 stainless steel hardware.
8. A polypropylene drip tray shall be provided for each pump.
9. Piping shall be as specified by system below.
10. Valves shall be as specified by system below.
11. Unions shall match piping system.
12. Seals shall match piping system or as specified by system below.
13. Two chemical interface ports shall be provided one suction and one discharge. The configuration of connections shall be as specified by system below.
14. System shall have a two-year manufacturer's warranty.
15. The skid systems may be the product of the chemical pump manufacturer or manufacturer's approved representative.
16. Skid shall have built-in containment with sloped deck and drain fitting connection to allow any maintenance fluids or spills to gravity drain out of skid containment.
17. Skid shall be provided with removable spray shield. The spray shield shall be constructed of polycarbonate material to allow for clear view of skid components from 3 sides.

2.02 SODIUM HYPOCHLORITE SYSTEM

A. Sodium hypochlorite system consists of the following:

Item	Details	Remarks
Chemical detail	5.37% sodium hypochlorite (NAOCL)	
Day Tanks	2 x 545 gallons XLPE Tank	See Section 43 41 66 for details
SH Transfer Pump	1 pump complete with accessories installed	Magnetic Drive Gear Pumps for Chemical Service, See Section 46 33 33 for pump details
SH Recirculation Pumps	4 pumps complete with accessories installed	Magnetic Drive Gear Pumps for Chemical Service, See Section 46 33 33 for pump details.
SH Raw Water Pipe Feed Pumps	2 pumps complete with accessories installed on a skid	Peristaltic Tube Pumps, See Section 46 33 44 for pump details
SH Filter Inlet Channel Feed Pump	1 pumps complete with accessories installed on a skid	Peristaltic Tube Pumps, See Section 46 33 44 for pump details
SH Combine Filter Outlet Pipe Feed Pumps	2 pumps complete with accessories installed on a skid	Peristaltic Tube Pumps, See Section 46 33 44 for pump details
SH Backwash Pipe Feed Pump	1 pumps complete with accessories installed on a skid	Peristaltic Tube Pumps, See Section 46 33 44 for pump details
Pump skid material	FRP or HDPE	
Piping material	CPVC single wall, CPVC double containment pipe	CPVC Double Containment, See Section 40 05 31.19
Valves	CPVC vented ball valves and ball check valves	
Accessories	Calibration column, pressure relief valves, flow metering, pressure switches, tube failure/leak detection sensors,	
Wetted Materials	CPVC, FPM/Viton, PTFE, Hastelloy C-276	
Connection Details	Suction: Flanged, ASME 150 Discharge: Socket	

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the Manufacturer's instructions and recommendations. Installation shall be certified by the Subcontractor on Form 43 05 11-A as provided in Section 01 99 90.

B. Anchor bolts and other hardware required for the installation shall be provided by the Contractor.

C. The equipment must be balanced and leveled to ensure proper operation.

3.02 SPARE PARTS AND SPECIAL TOOLS

A. Provide the Manufacturer's recommended spare parts for the initial two years of operation.

B. Provide special tools required for maintenance of the system.

3.03 STARTUP AND TESTING

A. Start-up and commissioning shall be performed in accordance with 01 45 20. The Supplier shall provide a factory representative, knowledgeable of the system and components, to inspect the final installation, supervise the initial operation, and train necessary personnel in the proper operation and maintenance for the system.

3.04 TRAINING

A. The Subcontractor shall provide the services of a factory-trained Manufacturer's representative to provide training for a minimum of 4 hours for each system. Prior to final acceptance, the Manufacturer's representative shall complete and provide supplier's Certification of Training on Form 43 05 11-B as provided in Section 01 99 90.

END OF SECTION

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SECTION 46 33 33

POLYMER BLENDING AND FEED EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies a packaged polymer blending units suitable for metering and diluting of liquid polymers. The units shall be suitable for the feed of all types of liquid polymers specified in this Section.

B. Type:

1. The polymer blending units shall be capable of pumping the required amount of liquid polymer from a bulk storage tank, mixing the polymer with the correct amount of dilution water in the mixing chamber, and feeding the blended polymer solution to the batch day tank. The blending unit shall automatically adjust the amount of polymer and dilution water to maintain the required diluted neat concentration. The polymer blending feed equipment shall consist of the following components:
   a. Non-mechanical liquid polymer activation chamber
   b. Neat polymer metering pump
   c. Water booster pump
   d. Polymer check valve
   e. Clear solution discharge piping
   f. Local control panel with metering pump SCR controller
   g. Stainless steel frame
   h. Polymer flow meter
   i. Dilution water flow meter
   j. Clear calibration column
   k. Associated pressure gauges, pressure switches, transmitters, valves and solenoid valves required for operation detailed in this Section.

C. Equipment List:

Item	Equipment No.
Polymer Blending Unit 1	84 -BLND-10010
Polymer Blending Unit 2	84-BLND-20010

D. Operating Conditions:

1. Each polymer blending unit shall be provided with its own dedicated local control panel to allow for manual and fully automatic control as described in this specification section.

E. Performance Requirements:

1. Each packaged aqueous polymer blending unit shall be designed for continuous duty under the following operating conditions:

Item	Value
Neat polymer feed rate, gallons per hour	
Maximum	1.5
Minimum	1.5
Diluted neat polymer feed rate, gallons per hour	
Maximum[c]	596.7
Minimum[c]	4.9
Required Discharge Pressure, psig	
Maximum	2
Minimum	1
Dilution water supply pressure, psig	
Maximum	60
Minimum	40

[c] *Based on a solution output concentration of 0.25 percent.*

F. Design Requirements:

1. The polymer blending unit shall be designed to handle the following types of neat polymer:

Item	Value
Neat polymer specific gravity	
[Emulsion]	1.10
Neat polymer active concentration range, percent	
[Emulsion]	20-45
Neat polymer viscosity range, centipoise	
[Emulsion]	20.5

G. Environmental Conditions:

1. Ambient conditions are specified in Section 01 11 80.

H. Seismic:

1. Equipment, skid, and supports shall be braced per Section 01 73 24.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A276	Stainless Steel Bars and Shapes
ASTM A320/A320M	Alloy/Steel Bolting Materials for Low-Temperature Service
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
NFPA 70	National Electrical Code (NEC)

B. Unit Responsibility:
   1. This manufacturer is the unit responsibility manufacturer and has unit responsibility, as specified in Section 43 05 11-1.02 Unit Responsibility, for both the equipment assembly specified in this section and for the Local Control Panel specified in this section and in Section 40 67 00. A completed, signed, and notarized Certificate of Unit Responsibility (Section 01 99 90-Form 43 05 11-C) shall be provided.

C. Factory Tests:
   1. The specified equipment with all mechanical and electrical components shall be completely assembled as a skid at the manufacturer's facility. Pump casings shall be hydrostatically tested to twice the discharge head. The skid shall be non-witnessed tested for desired functionality and operation at the manufacturer's facility prior to the shipment.

D. Shipment, Protection, and Storage:
   1. Equipment shipment, protection, and storage shall conform to the requirements specified in Section 01 66 00.

E. Manufacturer's Experience:

F. Equipment furnished under this section shall be of a design and manufacture that has been successfully used in similar applications. The manufacturer shall have furnished equipment for a minimum of five similar applications that have been in successful operation for at least five years. A list of these installations complete with installation description, contact names, addresses, and telephone numbers shall be provided. Warranty And Performance Affidavit:
   1. The packaged aqueous polymer blending unit shall be warranted against defects in materials and workmanship of a period of 5 years.

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:

1. Shop Drawings:

a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

b. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked *"no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review*.

c. Completed Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. *No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.*

d. Motor Data Sheets specified in Section 43 05 21.

e. Marked copies of specification Sections 26 29 13, 26 09 16 and 40 67 00, with addendum updates included.

f. Manufacturer's specifications verifying the equipment performance. Motor data sheet.

g. Dimensional drawings, showing required access and clearances, including any layout requirements of the equipment.

h. Equipment mounting information as specified in Section 43 05 13.

i. Manufacturer's catalog data and shop drawings confirming dimensions, weight, construction, materials, and installation details.

j. Equipment control panels:

1) Schematic diagrams, including connections to remote equipment.

2) Drawings showing scaled front and interior views.

3) Bill of materials of components.

4) Marked product literature for all components.

k. Marked product literature for all instruments and controls.

l. Installation reference list including contact information as specified in this section.

m. Manufacturer's written certification that the polymer blending unit is suitable for the required polymer. The certification shall state that no additional equipment, such as aging tanks, are necessary.

n. Predicted performance curves developed for the specific application. Performance curves shall plot speed, capacity, head, horsepower, efficiency, and NPSH required for the specified operating range for the pumps provided on the skid.

o. Shop drawings including location of all piping, electrical, instrumentation, and structural connections.

p. Descriptive control sequences of the polymer blending unit's manual and automatic operation.

q. PLC program listing printout and SCADA Input/Output List per paragraph 2.04 Local Alarms. to support development of Plant Control System interface. If submittal is electronic, entire submittal electronic file shall be compressed to reduce file size.

r. HMI screen printouts.

2. Operation And Maintenance:

a. Applicable operation and maintenance information as specified in Section 01 78 23, including:

1) Final reviewed shop drawing submittal.

2) As-built drawings, PLC program listing, HMI screen printouts, and SCADA Input/Output list.

3) Range and setting of indicators, instruments, timers, and other related devices.

4) Equipment Warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this section. Candidate manufacturers include:

1. Velodyne, Veloblend VM Series
2. UGSI, Polyblend
3. Or approved equal

B. Candidate neat polymer metering pump include Moyno, or equal.

2.02 MATERIALS

A. Materials of components shall be as follows:

Component	Material
Mixing chamber	304 Stainless Steel Steel with PVC internal components
Polymer pump suction and bearing housing	Type 316 Stainless Steel
Polymer pump rotor	Type 316 Stainless Steel
Polymer pump drive shaft	Type 316 Stainless Steel
Neat polymer flow meter wetted parts	Type 316L Stainless Steel
Skid	Type 304 Stainless Steel

2.03 EQUIPMENT

A. General:

1. Each polymer blending unit shall be a complete package that automatically dilutes, activates and pumps liquid polymer and water. Blenders shall instantaneously invert neat polymer into solution, producing a thoroughly diluted and completed activated homogeneous blend, free of “fish-eyes” and unblended polymer. Units shall be capable of delivering a consistent dilute polymer solution at an adjustable rate of flow and concentration. Each unit shall be an integrated package, prepiped and prewired.

B. Liquid Polymer Mixing Chamber:

1. Provide a multi-staged, non-mechanical hydrodynamic blending device specifically designed to dilute and activate the specified solution type polymer with viscosity up to 75,000 cps and active contents up to 75 percent.
2. The liquid polymer mixing activation chamber’s mixing energy shall be staged such that it provides for high, non-damaging mixing energy over the full operating range of the system which then dissipates through a series of concentric chambers. The system shall be designed for use with potable dilution water. The type of dilution water used shall not affect the specified warranty in any way. A mixing chamber drain valve with ½-inch fitting shall be provided and routed to the nearest floor drain. The mixing chamber shall have a maximum rated pressure of 150 psi.
3. Provide neat polymer check valve designed to isolate neat polymer from dilution water. The valve construction shall be PVC or Teflon, stainless steel and/or Viton. The valve shall be readily accessible for cleaning and shall be easily disassembled. Valve shall be located outside of the mixing chamber and shall not require mixing chamber disassembly for servicing.
4. The maximum pressure drop across the mixing chamber shall be 50 psi.
5. Equip the mixing chamber with an adjustable pressure relief valve plumbed to the nearest drain.

C. Neat Polymer Metering Pump:

1. The stator shall be a one-piece molding of Viton with a minimum durometer hardness of 65. Bond the stator securely to the housing.
2. Pumps shall be provided with packing. Packings shall have stainless steel parts, Viton elastomers and carbon to tungsten carbide seal faces.
3. Drive shaft shall be solid and sized with ample safety factors to give a long operating life.

4. The rotor shall be joined to the drive shaft by means of a connecting rod with high strength, shock resistant universal joints. Universal joints shall be pin type, sealed and greased to prevent entrance of pumped fluid.
5. Stainless steel nameplates with raised lettering, indicating the manufacturer's model and serial number, rated capacity, head, speed and all other pertinent data, shall be attached to the pump.
6. The pump shall have a continuous output that includes the range indicated in this section. The pump shall have a minimum turndown range of 10:1. The pump shall contain a minimum of four stages to minimize slip. The pump shall be mounted to the frame with a stainless steel bracket which positions the pump suction no more than 18-inches off the base to maintain ideal pump suction conditions.
7. The pump shall be driven by a DC motor directly connected to the gear reducer. The pump speed shall not exceed 585 rpm. The speed of the pump shall be controlled by an SCR motor controller mounted in the control panel.
8. The SCR motor controller shall be controlled manually and automatically at the local control panel.

D. Calibration Assembly:
   1. The blending unit shall be provided with a calibration assembly for the neat polymer metering pump. The calibration assembly shall be rigidly mounted onto the blending unit's frame. Supporting the calibration column using the polymer piping is not acceptable. The calibration assembly shall have both mL calibrations and direct reading flow in gallons per hour. Size the calibration assembly based on a 30 second draw down at 100 percent pump capacity.

E. Dilution Water Booster Pump (I&C: Confirm if this pump is to be supplied.):
   1. Provide an integrally mounted dilution water booster pump with the blending unit. The pump shall be designed to increase the dilution water pressure to satisfy the performance requirements specified in paragraph 1.01 Performance Requirements without cavitation or excessive vibration. All wetted parts shall be stainless steel.
   2. Manual and automatic controls shall be provided for the dilution water booster pump. The operator shall be allowed to start and stop the dilution water booster pump in manual mode. The dilution water booster pump shall be programmed to operate when the polymer pump is running and stop when the polymer pump is stopped in automatic mode. The dilution water booster pump shall also be programmed to automatically run on an operator entered system flush setpoint time prior to the blending unit shutting down.
   3. The dilution water booster pump shall automatically shutdown on low suction pressure or loss of dilution water flow.

F. Dilution Water Flow Control (I&C: Confirm if this control valve is to be supplied.):
   1. Dilution water flow control shall be accomplished using a motor actuated flow control valve. The flow control valve shall be an integral part of the blending unit. Flow control valves shall be constructed of stainless steel and brass designed to allow repair without disassembly of any other part of the blending unit.

2. The blending unit shall automatically adjust the flow control valve position to maintain the operator entered setpoint neat polymer concentration in manual and automatic mode of operation. The blending unit shall also control the flow control valve's position based on an operator entered dilution water setpoint flow rate to flush the system prior to shutdown.
3. The flow control valve shall be accompanied by a motor controlled ball valve for on/off control of the dilution water supply and the dilution water booster pump.

G. Other Instruments:
1. Instruments shall meet the requirements of Division 40.
2. Mixing chamber shall be provided with a differential pressure switch. Polymer pump shall be provided with a discharge pressure gauge and pressure switch. Dilution water shall be provided with a solenoid valve and flow indicator

H. Stainless Steel Skid:
1. Polymer blending unit components shall be integrally mounted on a frame. All pipe supports shall be stainless steel. No mild steel shall be used. The frame shall be constructed of 3/16-inch angle or structural stainless steel tubing. The panel supporting the control panel shall be a minimum 12 gauge thickness.
2. Secure piping, valves and other components with rigid clamps. The frame shall be designed for lifting and shall have holes for mounting on concrete pads.

I. Suction Assemblies:
1. Provide all necessary couplings and adapters to connect the polymer blending unit to the polymer storage unit.

J. Motors:
1. Motors shall conform to the requirements of Section 43 05 21. Motor enclosures shall be TEFC and corrosive/washdown rated.
2. Motors shall operate on 90 or 180 Vdc.

2.04 CONTROLS

A. Control Description:
1. Operator shall be allowed to start and stop the blending unit, set the polymer flow and dilution water flow using the local control panel's HMI when the HOA is in the Hand position.
2. Operator shall be allowed to enter the following operating parameters through the HMI when the HOA is in the Auto position:
   a. Polymer percent active concentration
   b. Average sludge concentration, percent
   c. Pound of polymer per ton of dry solids,
   d. Neat polymer specific gravity,
   e. Diluted neat polymer concentration, percent.
   f. Pre and post flushing times, seconds and
   g. Pre and post flush flow rates, gph.
   h. Polymer pump maximum capacity, gph

3. The blending unit PLC shall also be programmed to accept an external 4-20 mAdc sludge flow rate pacing signal and a remote start/stop signal (dry contact) signal The PLC shall perform all required calculations to determine the required polymer flow rate and dilution water flow rate based on the entered operating parameters and sludge flow pacing signal. The PLC shall automatically control the polymer metering pump and dilution water flow control valve to maintain the calculated neat polymer flow rate and setpoint diluted neat polymer concentration.
4. Prior to starting and stopping the polymer feed pump at the initiation of the remote start/stop signal, the blending unit shall initiate a start-up and shutdown flush in accordance with the operator entered setpoints.

B. Control Panels:
   1. Provide each unit with a control panel integral to the system's frame rated NEMA 4X and constructed of fiberglass reinforced plastic (FRP). The control panel shall consist of all switches, relays, indicator lights, digital displays, transformers, and controllers as required herein. The blender components shall be factory wired to the control panel for power supply and control in accordance with the Section 40 67 00.
   2. An external lockout/disconnect for 480 Vac, 3 phase electric power source shall be provided for each blending unit control panel.
   3. Control Panel Lights:
      a. Power ON indicator light.
      b. Common alarm light.
      c. Panel light colors shall meet the requirements of Section 40 67 00.

C. Control Devices: Provide the following control devices:
   1. Programmable Logic Controller (PLC) to control the operation of the blending unit in any mode of operation. PLC shall be Square D Modicon Momentum or approved equal.
   2. A liquid crystal display (LCD) touchscreen human machine interface (HMI) shall be provided for input of operating setpoints, alarm setpoints, monitoring of blending unit operation, and to acknowledge or clear alarm conditions. The polymer dilution and feed unit control panel shall have, as a minimum, the following displays and lights or be integrated into the HMI system:
      a. Actual polymer flow rate,
      b. Actual dilution water flow rate,
      c. Actual diluted neat polymer (solution) concentration,
      d. Hand-Auto status,
      e. Alarm setpoints and time delays,
      f. Alarm status, and
      g. Diluted neat polymer pressure.
   3. Hand–Off–Auto (HOA) switch.
   4. Heavy-duty emergency stop push button with red knob.

D. Interlocks:
   1. The polymer pump shall be interlocked to shutdown in any mode of operation on the following alarm conditions:
      a. Low neat polymer flow

b. High neat polymer discharge pressure
c. High mixing chamber differential pressure
d. Low dilution water flow
e. Low dilution water suction pressure

E. Local Alarms:
1. Polymer blending unit shall be capable of generating the following alarms with adjustable time delays:
a. Low mixing chamber differential pressure
b. High neat polymer discharge pressure
c. Low neat polymer flow (operator adjustable)
d. High neat polymer flow (operator adjustable)
e. Polymer blending unit failure when unit is unable to maintain the setpoint polymer flow rate and setpoint diluted neat polymer (solution) concentration.
f. Low dilution water flow (operator adjustable)

F. Remote Input And Outputs:
1. The polymer blending unit control panel shall provide the following alarms, control signals, and status signals to/from Plant Control System. Analog signals shall be 4 to 20 mADC, discrete inputs and outputs shall be dry contacts.
a. Control Inputs:
1) Remote start/stop
2) Neat polymer flow
3) Diluted neat polymer (solution) concentration
4) Neat polymer specific gravity
b. Control Outputs:
1) Metering pump speed.
2) Neat polymer flow rate
3) Dilution water flow rate
4) Diluted neat polymer (solution) flow rate
5) Diluted neat polymer (solution) concentration. The solution concentration is generated by the blending unit's PLC based on actual neat polymer flow, dilution water flow and polymer specific gravity entered at the HMI.
c. Status Outputs:
1) Neat polymer pump status (running or stopped)
2) Dilution water pump status (running or stopped)
3) Polymer blending unit control status (HAND or AUTO)
d. Alarm Outputs:
1) Common alarm

2.05 COATINGS

A. Equipment shall be shop primed prior to shipment from the factory with a primer compatible with the field applied coating specified in Section 09 90 00.

2.06 SPARE PARTS

A. Mechanical: The following spare parts shall be provided for each polymer blending unit of each size:
   1. Special tools required for operation and maintenance.
   2. One complete set of gaskets and o-rings for all gasketed covers and connections
   3. One neat polymer ball check valve assembly.
   4. One neat polymer pump rotor
   5. One neat polymer pump stator
   6. One neat polymer pump packing kit.
   7. One water booster pump packing
   8. One set of bearings for water booster pump
   9. One dilution water needle valve
      a. Spare parts shall be tagged and stored as specified in Section 43 05 11.

B. PLC Program:
   1. Provide two separate copies of PLC and HMI programs on CD-ROM. Label with Owner's name, facility name, project name, Owner's project number, LCP name, date, and PLC or HMI manufacturer's programming software used name; model; and revision/version. Programs shall be provided after completion of testing.

2.07 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's Installation Certification Section 43 05 11-Form A
   2. Manufacturer's Instruction Certification Section 43 05 11-Form B.
   3. Operating and maintenance information specified in Section 01 78 23.
   4. Motor data specified in Section 43 05 21.
   5. Manufacturer's Warranty specified in paragraph 1.02-F.1

PART 3 EXECUTION

3.01 INSTALLATION

A. The polymer blending unit shall be installed in accordance with the manufacturer's written recommendations, and] the requirements of Sections 43 05 13, 43 05 14. The installation and initial operation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 FIELD TESTING

A. Each polymer blending unit shall be field tested in accordance with the requirements of Section 01 45 20.

3.03 TRAINING

A. A minimum of 2 hours of training conforming to the requirements of Section 01 79 00 Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

END OF SECTION

MAGNETIC DRIVE CENTRIFUGAL PUMPS FOR CHEMICAL SERVICE

PART 1 GENERAL

1.01 SUMMARY

A. Scope

1. This Section specifies the furnishing of the self-priming magnetically driven centrifugal pumps for chemical service including centrifugal pumps, drive motors, pump control and all piping and appurtenances required for a complete operating installation as specified herein.
2. The Manufacturer shall review the mechanical layout and instrumentation drawings within the Contract Documents, which relate to the equipment specified in this Section to familiarize themselves with the location and the set-up of the equipment specified and shall assure themselves that the equipment specified is appropriate for and coordinated with that which is shown on the Drawings.

B. Equipment List

1. Numbered equipment, components, ancillaries and panels which are in the scope of supply of this Section are as follows.

Item	Equipment Number
Sodium Hypochlorite Transfer Pump	89-P-00010
Sodium Hypochlorite Recirculation Pumps	89-P-00020, 89-P-00030, 89-P-00040, 89-P-0050
Pressure Gauges and Switches	
Backpressure Valve	

C. Performance Requirements

1. The equipment described in this Section shall meet the following design minimum operating requirements.

Item	Required value
SH Transfer Pump (Equipment Tag: 89-P-00010) SH Recirculation Pump 1 & 2 (Equipment Tag: 89-P-00020 & 89-P-00030) SH Recirculation Pump 3 & 3 (Equipment Tag: 89-P-00040 & 89-P-00050)	
Service	Sodium Hypochlorite
Maximum Flow, gpm	60
Minimum Flow, gpm	20
Maximum Pressure, feet	41

Item	Required value
Average Pressure, feet	55
Maximum Speed, rpm	3450
Horsepower, hp	2
Pump Model Number	SP15
Back Pressure Valves	
Inlet Pressure (psig)	10
Outlet Pressure (psig)	2
Drive Motor	
Drive type	Self-priming, magnetic drive, constant speed provided by the Manufacturer of the driven equipment.
Voltage, V/Phase	480/3
Hertz, Hz	60

2. Fluid Characteristics: The pumping system shall be suitable for pumping the chemicals described below:
   a. Sodium Hypochlorite
      1) Formula: NaOCl
      2) Solution Concentration: 5.37% percent by weight
      3) Solution Temperature: 35 to 100 degrees Fahrenheit
      4) Solution pH: 11
      5) Solution Specific Gravity: 1.08 at 68 degrees Fahrenheit
3. Pumps: Dry self-priming, capable of being run dry for up to 5 minutes without damaging effects to pump, with a maximum suction lift capability and pressure rating as schedule.

1.02 QUALITY ASSURANCE

A. Reference Codes and Standards

1. This Section contains references to the following documents. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference Title	Specific Section and Paragraph, if applicable	Version, if other than latest as of February 2016
ASTM A743/A743M-88 Castings, Iron-Chromium, Iron-Chromium-Nickel, and Nickel-Base Corrosion-Resistant for General Application	Entire Document	-
California Building Code (CBC)	Entire Document	-
NEMA MG 1 Motors and Generators	Entire Document	-
NEMA ICS 1 Industrial Control and Systems General Requirements	Entire Document	-

B. Unit Responsibility

1. Unit Responsibility in accordance with Section 43 05 11 – General Requirements for Equipment to warrant, design, manufacture, Factory Test, provide proof of seismic requirement compliance as required by this Section, ship, provide coordination of installation, provide all specified Field Testing and Facility Startup, Training, and Operations and Maintenance Manuals for all the equipment specified in this Section. A Certificate of Unit Responsibility Form shall be furnished for the equipment specified in this Section.

C. Factory Testing

1. Factory Testing shall be performed by the Manufacturer prior to delivery in order to verify the accuracy and performance of the systems as specified. Factory Testing need not be witnessed by the Engineer unless a special Witness Testing paragraph is included in this Section. However, the Manufacturer shall certify and provide copies of the tests and guarantee the equipment's performance as specified in this Section. All certifications of Factory Testing shall be submitted and approved by the Engineer prior to shipping equipment.
    a. Provide one (1) month advanced notice of factory testing schedule
2. All factory wiring shall be tested.
3. Factory Testing shall include at the minimum all standard tests recommended by the Manufacturer and the following:
    a. Flow at 100 percent of stroke speed and 100 percent stroke length at maximum pressure
    b. Flow at 50 percent stroke speed and 50 percent stroke length at maximum pressure

D. Warranty

1. A warranty for the equipment specified under this Section shall be provided in accordance with the General Conditions. The Warranty shall be for one (1) year from the date of the Notice of Substantial Completion certificate issued by the Owner for the Work. If extended warranties are required, a special paragraph calling for an extended warranty will be included in this Section.

1.03 AREA EXPOSURE DESIGNATIONS AND ENVIRONMENTAL CONDITIONS

A. Refer to Section 01 61 45 – Area Exposure Designations for site-wide area exposure designations and environmental conditions.

B. Refer to Section 01 11 80 – Environmental Conditions for site environmental conditions.
   1. Exposure: Indoor
   2. Environmental: Chemical Sodium Hypochlorite

1.04 SUBMITTALS

A. Action Submittals-Preconstruction: The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 01 33 00 - Submittals.
   1. A copy of this Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (✓) shall denote full compliance with a paragraph as a whole.
   2. If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations.
   3. The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.
   4. For all equipment specifications, a copy from the Drawings of the control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this Section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the diagrams shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   5. Certificate of Unit Responsibility attesting that the Contractor has assigned unit responsibility in accordance with the requirements of this Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   6. Equipment literature, cut-sheets and data-sheets for all equipment supplied under this Section, including specifications, size, weight, performance data, pump performance curve, Manufacturer startup required inlet pressure, flow rate, motor horsepower and speed. This shall include accessories including pressure valves, pulsation dampers, and calibration column.
   7. Performance calculations.

8. Dimensional drawings for the equipment supplied under this Section. In addition to dimensional information for the equipment specified, these drawings shall dimensionally show the connection points and sizes for piping, electrical, instrumentation, water supply, and structural connections. Dimensional drawings to include location of piping connections, fitting sizes, and minimum clearance requirements for operation and maintenance.
9. Weights for the provided equipment and major components.
10. Information and chemical compatibility regarding the materials of construction for all equipment supplied under this Section.
11. Shop painting systems, including descriptive technical catalog literature and specifications.
12. Section 43 05 13 – Rigid Equipment Mounts
13. Complete list of recommended spare parts, irrespective of what spare parts are required to be supplied under this scope of supply.
14. Warranty information.
15. Operation and maintenance information in accordance with Section 01 78 23 - Operations and Maintenance Data.
16. Special shipping, storage and protection, and handling instructions.
17. Installation Instructions.
18. Submit calibration charts and tables relating flow rate to speed control.
19. Electrical elementary diagrams, internal connection diagrams, and external interconnection diagrams. Connection diagrams shall be the conventional type with lines showing point-to-point wiring and must show terminals and devices as viewed by the electrician; wireless or wire schedule types are not acceptable.
20. Catalog data on all ancillary electrical components, including limit switches and instruments.
21. Motor Data in accordance with Section 26 05 84 – Electric Motor.

B. Action Submittals-Construction: The following additional submittals shall be submitted in accordance with Section 01 33 00 - Submittal Procedures through the construction of this element of the Work.
   1. Factory Test Report
   2. Field Testing Plan
   3. Field Test Reports

C. Closeout Submittals: The following minimum closeout submittals shall be submitted in accordance with the timing requirements specified in these Contract Documents, prior to Substantial Completion and in accordance with Section 01 33 00 - Submittal Procedures.
   1. Operations and Maintenance Manuals (including Warranty) in accordance with Section 01 78 23 - Operations and Maintenance Data
   2. Certificate of Proper Installation
   3. Certificate of Field Testing and Commissioning
   4. Certificate of Training Completion

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Manufacturers: Candidate manufacturers are listed below. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Magnetically Driven Centrifugal Pump:
      1) SP by Finish Thompson
      2) TE Series by March Pumps
   b. Back Pressure Valves:
      1) Plast-O-Matic, Series RVDT;
      2) Asahi/America, or
      3) Approved Equal.

2.02 STRUCTURAL DESIGN REQUIREMENTS FOR EQUIPMENT

A. Equipment shall be provided in accordance with Section 01 73 24 - Design Requirements for Non-Structural Components and Non-Building Structures.

2.03 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose. If alternatives are proposed, the proposals shall be accompanied with documentation supporting the claimed superiority of the proposed substitutions. The Engineer shall be the sole decider in the equivalency of alternative materials of construction.

B. Magnetically Driven Centrifugal Pump
   1. Chemical Resistance: All equipment and materials utilized in the chemical system shall be resistant to the chemical being fed and shall be so certified by the Manufacturers. The pumps and appurtenances shall be certified corrosion resistant materials and construction suitable for the chemical being pumped at the pressures specified in the pump schedule and at a maximum temperature of 125 degrees Fahrenheit. Wetted parts of all pumps and appurtenances shall be selected by the Manufacturer to ensure optimum corrosion and erosion-free operations. The Contractor shall verify the chemical resistance and compatibility of materials before installation.
   2. All surfaces that come into direct contact with the fluid being pumped must be either alumina ceramic, graphite impregnated silicon carbide, Viton, Hastelloy C or peek, as scheduled depending on service.
   3. All pump housings are to be constructed of PVDF.
   4. The gear set (driver and idler) must be non-metallic. Non-metallic gear material shall be carbon reinforced ETFE or as scheduled. All gear materials shall be non-sparking for use with hazardous fluids.

5. Shafts shall be made of alumina ceramic material. Metallic shafts are not acceptable.
6. Driven and drive magnets shall be made from rare earth Neodymium Iron suitable for temperatures up to 300 degrees Fahrenheit without degradation of magnetic strength. Other materials such as ceramics or rare earth Samarium Cobalt are not acceptable.
7. Driven magnet assemblies shall be fully encapsulated in carbon-reinforced ETFE
8. Drive magnet assemblies must be nickel plated on all exterior surfaces to minimize atmospheric corrosion.
9. Pump containment shell is to be 100 percent carbon-reinforced ETFE material. Any metallic components, linings and/or outer shell reinforcements are not acceptable.
10. Pump must be designed for close-coupled mounting to both standard NEMA and IEC motor configurations through the use of a non-metallic motor adapter.
11. All external hardware shall be 300 series stainless steel.
12. When applicable, each pump shall have a single, corrosion resistant baseplate that is structurally adequate to prevent misalignment or vibration.
13. All pump casings connections shall have either American Standard taper pipe threads or ANSI 150 number raised face flanges.

C. Motor and Drive
1. Valve Body: CPVC or PVC.
2. U-Cup Seals:
   a. Hypochlorite Service: Viton.
3. Adjusting bolt, locknut, control spring and fasteners: Stainless steel.

2.04 EQUIPMENT

A. Magnetically Driven Centrifugal Pump
1. Pumps shall be designed to isolate the pump body from the motor by driving a magnet and impeller assembly with a magnet attached drive to the motor shaft.
2. Pump shall be seal-less and ensures leak-free operation.
3. Pump shall be capable of withstanding a temporary upset condition of up to 5 minutes in which the pump is left to run dry without sustaining any damage to pump internals. Pumps without run dry capability are not acceptable.
4. Pump Construction:
   a. All gears shall be molded integral to the associated shaft. Gear mounting hardware such as retaining rings or gear keys are not acceptable.
   b. Pump bearings are to be of the internal sleeve type design and shall include spiral grooves so that they are properly cooled and lubricated by the pumped fluid. Pumps relying in external bearing lubrication systems shall not be acceptable.
   c. Bearings and wearplates shall be of the one-piece integral design. Separate bearings and wear plates are not acceptable.

d. Driven magnet assemblies shall be fully encapsulated in carbon-reinforced ETFE. Design must include spline drive geometry to allow for ease of alignment and assembly. Mechanical locking of the driven magnet to the drive shaft by any other means is not acceptable.

e. Drive magnet assemblies must be nickel plated on all exterior surfaces to minimize atmospheric corrosion. Drive magnet carrier must include a removable motor mounting hub for use with multiple motor frame sizes. Integral (one piece) drive magnet carriers and hubs are not acceptable.

f. Pump containment shell is to be 100 percent carbon-reinforced ETFE material. Any metallic components, linings and/or outer shell reinforcements are not acceptable. Containment shell must be sealed from the environment by use of an elastomeric o-ring. Gaskets or other sealing devices are not acceptable.

g. Pump must be designed for close-coupled mounting to both standard NEMA and IEC motor configurations through the use of a non-metallic motor adapter.

h. NPSH required for pump operating conditions shall not exceed 2 feet.

i. Pumps shall be self-priming

j. Open loop flow repeatability shall be within plus or minus 5 percent.

k. All external hardware shall be 300 series stainless steel.

l. All typically wearing parts of the pump shall be replaceable without disturbing the process piping.

m. When applicable, each pump shall have a single, corrosion resistant baseplate that is structurally adequate to prevent misalignment or vibration.

n. All pump casings connections shall have either American Standard taper pipe threads or ANSI 150 number raised face flanges.

B. Motor and Drive

1. Refer to this Section, Paragraph 2.05 Electrical Components and Accessories for additional motor and drive requirements.
2. Motors shall be provided by the Manufacturer of the driven equipment in accordance with this Section and Section 26 05 84 – Electric Motors.
3. Motors and drives shall be mounted as specified in this Section and as shown on the Drawings. Alternative configurations will not be considered.
4. Gearbox: Output shaft and face shall accept the direct coupling of the pump head
5. Gearing: Manufactured in accordance with AGMA Class 11-12 requirements with an overall gearbox rating of AGMA class II under continuous operation.

C. Pressure Gauges and Switches

1. Provide pressure gauges and switches as specified in Section 40 73 00.

D. Backpressure Valve

1. The equipment Manufacturer shall furnish corrosion-resistant backpressure valves on the discharge of each chemical pump (near discharge return to day tank). Backpressure valves shall be the diaphragm type with a pre-set pressure spring and be of CPVC construction with a PTFE-coated diaphragm. Backpressure valves shall be sized for the following maximum flows.

2.05 ELECTRICAL COMPONENTS AND ACCERSORIES

A. Electrical components shall be listed for the purpose for which they are to be used by an independent testing laboratory acceptable to the inspection authority having jurisdiction per specification section 26 05 00 Common Work Results for Electrical

B. Electrical components shall be tested per the requirements specified in specification sections 01 45 20 Equipment and System Performance and Operational Testing and 26 08 00 Commissioning of Electrical Systems.

C. Where a motor is specified, unless otherwise indicated, the motor shall be provided in accordance with Section 26 05 84 – Electric Motors.

D. Electrical equipment shall include arc flash hazard labels as specified in specification section 26 05 00 3.01 C Common Work Results for Electrical– Electrical Equipment Labeling.

E. All factory wiring required for equipment specified under this section shall be included and shall have been tested for installation integrity as part of factory testing specified in this section.

F. Field installed raceway and wiring required for the functional operation of the equipment specified in this section is defined on the electrical drawings and schedules based on the first named equipment Manufacturer specified in this section. Any additions or modifications to field wiring, raceway requirements, upstream overcurrent protection, related motor controllers or variable frequency drives being provided for the operation of driven equipment included in this specification shall be included under the work of this section and shall be installed per the specified requirements of the Division 26 electrical specifications.

G. Provide nameplates on electrical equipment and control panels (where included under this section) as specified in specification section 26 05 00 - Common Work Results for Electrical.

2.06 INSTRUMENTATION

A. Instrumentation and control devices shall be provided in accordance with the provisions of Division 40.

2.07 SAFETY ENCLOSURES AND MEASURES

A. Equipment shall have adequate removable enclosures to protect personnel against accidental contact with moving parts and prevent dripping in multilevel installations in accordance with the guards and caution sign requirements in Section 43 05 11 – General Requirements for Equipment.

2.08 NAMEPLATES

A. Equipment nameplates shall be provided on each item of equipment, including the primary equipment supplied, valves, operators and all other major appurtenances that are part of the scope of supply of this Section. Unless otherwise specified, equipment nameplates shall be provided in accordance with technical requirements described in Section 43 05 11 - General Requirements for Equipment.

B. Electrical nameplates shall be provided on each electrical item supplied including control panels and variable frequency drives which are part of the scope of supply of this Section. Unless otherwise specified, electrical nameplates shall be provided in accordance with the technical requirements of Section 26 05 00 - Common Work Results for Electrical.

C. Motor nameplates shall be provided on each motor supplied which are part of the scope of supply of this Section. Unless otherwise specified, motor nameplates shall be provided in accordance with the technical requirements of Section 26 05 84 - Electric Motors.

2.09 ANCHOR BOLTS

A. Furnish all anchor bolts in accordance with Section 05 05 20 – Anchor Bolts of ample size and strength required to securely anchor each item of equipment.

2.10 COATINGS

A. Coatings shall be factory-applied and provided in accordance to Section 09 90 00 – Painting and Coating.

2.11 SPARE PARTS

A. The following spare parts and special tools shall be provided in accordance with Section 01 60 00 – Product Requirements.

Spare Parts	Quantity
Complete spare pump and motor	1

B. One (1) set of any special tools required to perform operation and maintenance activities and perform installation.

C. Manufacturer shall provide a one (1) year supply of lubrication greases required for maintaining all screen components.

PART 3 EXECUTION

3.01 MANUFACTURERS FIELD SERVICES

A. Manufacturer shall provide field services in accordance with Section 01 60 00 – Product Requirements and as further required within this Section.

B. Manufacturer shall provide assistance during equipment installation as required by the Contractor.

C. The equipment provided under this Section shall be started and tested only under the direction of personnel provided by the Manufacturer.

D. The Contractor shall furnish the services of competent factory representatives familiar with the installation of their respective equipment to supervise the installation of the equipment and their appurtenances. The Manufacturer's factory representative shall be present at frequent enough intervals to ensure proper installation testing and initial operation of equipment.

3.02 SHIPMENT AND STORAGE

A. Equipment shall be shipped and stored in accordance with Section 01 60 00 – Product Requirements.

B. Manufacturer shall provide Contractor with detailed recommendations and instructions for equipment storage.

C. Packing and Shipping:
   1. Pack as required for shipping and outdoor storage at the project Site for up to 12 months. Apply temporary corrosion protective coatings to all unpainted components and pack components to protect the elements.

D. Storage and Protection: Protect the pump system and components at the Site and during installation prior to project completion. Apply protective coatings and manually rotate shaft regularly as recommended by the Manufacturer:
   1. Inspect and inventory items upon delivery to Site.
   2. Store and guard equipment, material, instructions, and spare parts in accordance with Manufacturer's written instructions.

3.03 INSTALLATION

A. Equipment shall be installed in accordance with Section 43 05 11 – General Requirements for Equipment.

B. Manufacturer's services: On-site inspection and training: Provide a factory-trained manufacturer's representative at the site for the following activities. Specified durations do not include travel time to or from the site.
   1. Installation inspections: Assist, supervise, and inspect the Contractor's activities during installation. Provide 8 inspection hours. Provide a completed Form 43 05 11-A, Section 01 99 90.
   2. Training sessions: Procedures Section 01 79 00. Provide a minimum of 2 hours classroom training for each training session. Conduct one training session to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 43 05 11-B, Section 01 99 90.

C. The equipment shall be aligned, connected, and installed at the locations shown and in accordance with the recommendations of the Manufacturer.

D. All material and equipment shall be clean and free of oil, grease, or chemical contamination on process surfaces prior to installation.

3.04 FIELD TESTING

A. Field Testing shall be in accordance with the requirements of Section 01 45 20 – Equipment and System Performance and Operational Testing.

B. The Manufacturer shall provide detailed procedures for the Field Testing of the equipment specified in this Section.

C. Field Testing shall be performed under the direction of experienced and qualified personnel provided by the Manufacturer.

D. Operational test phase inspections: Assist, supervise, and inspect the Contractor's activities during the operational test phase specified in Section 01 45 20 Provide 8 inspection hours.

3.05 TRAINING

A. Training shall be provided as specified in Section 01 79 00 – Demonstration and Training.

B. Training sessions: Procedures Section 01 79 00. Provide a minimum of 4 hours classroom training for each training session. Conduct one training session to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 43 05 11-B, Section 01 99 90

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SECTION 46 33 44

PERISTALTIC METERING PUMPS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies pumps and accessories for feeding anionic polymer (PEA) and fluoride for the purpose of flocculation aid, filtration aid, waste backwash water aid, sedimentation basin solids settling aid, and fluoride addition.

B. Type:

1. The metering pumps shall be of positive displacement, peristaltic type utilizing a flexible tube and spring-loaded roller or track. The pump shall be suitable for metering service with adjustable speed drives to control the dosage with accuracy of one percent variation from the pump setting. Each pumping unit shall be complete with pump, drive unit, base, and all appurtenances to provide a complete pumping system for the specific process fluids and design characteristics as specified herein.

C. Equipment List:

Equipment Description	Equipment Number
PEA Feed Pump 1	84-P-00020
PEA Feed Pump 2	84-P-00030
PEA Feed Pump 3	84-P-00040
PEA Feed Pump 4	84-P-00050
PEA Feed Pump 5	84-P-00060
Sodium Hypochlorite Feed Pump 1	89-P-00060
Sodium Hypochlorite Feed Pump 2	89-P-00070
Sodium Hypochlorite Feed Pump 3	89-P-00080
Sodium Hypochlorite Feed Pump 4	89-P-00090
Sodium Hypochlorite Feed Pump 5	89-P-00100
Sodium Hypochlorite Feed Pump 6	89-P-00110

D. Performance and Design Requirements:

1. General:

a. The metering pumps and equipment shall be designed and selected for pumping the following chemical solutions:

Chemical	Solution Density[1]	Concentration (wt/wt)
Anionic Polymer	9.17	100%
Sodium Hypochlorite	1.08	5.37%

[1] Solution density, lb per gal @ 68 degrees F

b. Pump operation shall be automatic mode. Adjustable speed drives shall be controlled by a 4-20 mA signal from SCADA.

2. Design Requirements:
   a. The metering pumps shall be designed for continuous duty under the following operating conditions:
      1) Size pumps so the average chemical feed rate is only 30% of the pump's maximum feed rate.

Equipment Numbers	84-P-00020, 84-P-00030 (Filter Inlet)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	0.3	gph
Average chemical feed rate	6.2	gph
Maximum chemical feed rate	26.7	gph
Operating pressure	10	psi
Maximum discharge pressure	20	psi
Maximum power consumption	135 VA	hp or VA
Maximum rotor speed	220	rpm
Power supply	120/60/1	V/Hz/phase

Equipment Number	84-P-00040 (Flocculation)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	1.6	gph
Average chemical feed rate	12.4	gph
Maximum chemical feed rate	53.4	gph
Operating pressure	10	psi
Maximum discharge pressure	20	psi
Maximum power consumption	135 VA	hp or VA
Maximum rotor speed	220	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	84-P-00050 (Waste Backwash Collection Box)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	0.4	gph
Average chemical feed rate	4.3	gph
Maximum chemical feed rate	17.3	gph
Operating pressure	10	psi
Maximum discharge pressure	20	psi
Maximum power consumption	135 VA	hp or VA
Maximum rotor speed	220	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	84-P-00060 (Solids Collection Box)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	0.0	gph
Average chemical feed rate	0.1	gph
Maximum chemical feed rate	12.0	gph
Operating pressure	10	psi
Maximum Discharge Pressure	20	psi
Maximum power consumption	135 VA	hp or VA
Maximum rotor speed	220	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	89-P-00060, 89-P-00070 (Raw Water)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	6.4	gph
Average chemical feed rate	12.7	gph
Maximum chemical feed rate	38.0	gph
Operating pressure	3.0	psi
Maximum Discharge Pressure	TBD	psi
Maximum power consumption	TBD	hp or VA
Maximum rotor speed	TBD	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	89-P-00080 (Filter Inlet)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	6.3	gph
Average chemical feed rate	12.7	gph
Maximum chemical feed rate	25.4	gph
Operating pressure	3.0	psi
Maximum Discharge Pressure	TBD	psi
Maximum power consumption	TBD	hp or VA
Maximum rotor speed	TBD	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	89-P-00090, 89-P-00100 (Filter Effluent)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	6.3	gph
Average chemical feed rate	12.7	gph
Maximum chemical feed rate	25.4	gph
Operating pressure	6.0	psi
Maximum Discharge Pressure	TBD	psi
Maximum power consumption	TBD	hp or VA
Maximum rotor speed	TBD	rpm
Power supply	120/60/1	V/Hz/phase]

Equipment Number	89-P-00110 (Backwash)	
Parameter	**Design Value**	**Units**
Minimum chemical feed rate	9.9	gph
Average chemical feed rate	19.9	gph
Maximum chemical feed rate	44.7	gph
Operating pressure	6.0	psi
Maximum Discharge Pressure	5.5	psi
Maximum power consumption	TBD	hp or VA
Maximum rotor speed	TBD	rpm
Power supply	120/60/1	V/Hz/phase]

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A743/A743M-88	Castings, Iron-Chromium, Iron-Chromium-Nickel, and Nickel-Base Corrosion-Resistant for General Application
NEMA MG 1	Motors and Generators
NEMA ICS 1	Industrial Control and Systems General Requirements

1.03 ENVIRONMENTAL CONDITIONS:

A. The equipment shall be located indoors in heated and ventilated areas. Environmental conditions are as described in Section 01 11 80.

1.04 SUBMITTALS

A. The following submittals shall be provided as specified in Section 01 33 00:
   1. Shop drawings with complete dimensions and mounting details for the pumps.
   2. Catalog data and information including:
      a. Maximum and minimum capacity using adjustable speed drive, gpm; maximum and minimum operating speed, rpm; and discharge pressure.

b. Motor and adjustable speed drive type.

3. Materials of construction.
4. Net positive suction head required.
5. Manufacturer's wiring diagram.
6. Manufacturer's catalog data on all accessories including pressure regulating valves, pressure relief valves, flow calibration chambers, and suction assemblies.
7. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
8. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
9. A copy of all related contract schematic, structural, and mechanical drawings with all piping, foundations, supports, and layout sizes and dimensions requiring Contractor confirmation marked.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s product, nor shall it be construed that a named manufacturer’s standard product will comply with the requirements of this Section. Candidate manufacturers include Watson Marlow or approved equal.

2.02 GENERAL

A. The manufacturer shall furnish all meter pump system equipment to complete a properly functioning, integrated package as intended by these specifications. The system shall be factory-assembled to the maximum extent practical. Factory assembly shall include all pumps, motors, bases, drives, and appurtenant valves and fittings. Any component parts not pre-assembled due to packaging and shipping concerns shall be identified and clearly labeled. No field welding will be allowed.

B. All materials used for the metering pumps and accessories shall be designed by the manufacturer to have the necessary strength, stability and stiffness for the intended service. All connections, foundation bolts, plates, nuts, washers and clamps shall be corrosion resistant to the conditions of use.

2.03 MATERIALS

A. The peristaltic metering pumps shall be manufactured of the following materials:

Equipment Number	84-P-00020 to 84-P-00060
Case	Die-cast aluminum
Track	Polyphenylene sulfide
Rollers	316 stainless steel
Bearings	316 stainless steel with PTFE seals
Drive shaft	Nickel plated steel

Equipment Number	87-P-00040, 87-P-00050
Case	Die-cast aluminum
Track	Powder coated aluminum
Rollers	303 stainless steel with Nylatron guide
Bearings	Carbon steel
Drive shaft	440C stainless steel

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.04 EQUIPMENT

A. Pump and Drive Mechanism:

1. Pump shall be of the positive displacement peristaltic type utilizing a flexible tube. The tubing shall be in contact with the inside diameter of the track (housing) and be held in place on the suction and discharge by a hand adjustable clamp mechanism. Tube clamps requiring tools are not acceptable. Suction and discharge shall be on the same side of the pump head. The tubing shall be replaceable with no disassembly of the pump head and without the use of tools. Each pump shall consist of track/pump head cover with safety lock-out switch, screw down retainer mechanism, roller rotor assembly with integral adjustable speed drive. The lock-out switch shall render the drive inoperable when opened. The pump head shall be easily secured to the drive and be self locating.
2. Each pump shall be capable of self priming when completely dry with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or tubing. The pump shall require no check valves or diaphragms and shall not require any dynamic seals in contact with the process fluid. The process fluid shall only be in contact with the inside of the pump tubing.
3. Pumps shall be configured to conform with space constraints as shown in the Contract Drawings.

B. Tubing:
   1. The manufacturer shall furnish the appropriate hose material for the conditions of use (e.g., extruded Marprene, Neoprene, Silicone, PVC, or Viton). The tubing shall be of 64 shore A durometer.
   2. Pump tubing diameter may vary for different drive sizes. For drive speeds ranging from 10 to 360 rpm, the pump must accept tubing with a wall thickness of 3/16 inch and an inside diameter ranging from of 3/4 inch to 1 inch. For drive speeds ranging from 5 to 265 rpm, the pump must accept a wall thickness of 1/8 inch and a variation in inside diameter ranging from 1/2 inch to 5/8 inch. For drive speeds ranging from 10 to 220 rpm, the pump must accept tubing with an inside diameter of 1/8 inch.

C. Rotor Assembly and Track:
   1. The rotor assembly shall be equipped with two or four self lubricating geared compression rollers mounted on spring loaded arms. Rotor material of construction shall be as specified in paragraph 2.03 Materials. Compression rollers shall be symmetrical about the rotor for compression of the hose against the track. The track material shall be as specified in paragraph 2.03 Materials, and if cast aluminum; shall be factory coated with trimite polyurethane. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent back flow or siphoning. The pumping action shall be created by the occlusion of the pump hose and its subsequent restitution causing a vacuum effect to draw the fluid into the suction side of the hose. Hose occlusion shall be adjustable with a lead screw, which limits the travel of the spring, loaded roller.

D. Piping Connection:
   1. Adapters and connective fittings between the flexible tubing and the fixed piping shown on the Contract Drawings shall be provided by the manufacturer for each size tubing that is compatible with each pump.

E. Valves
   1. Adjustable diaphragm backpressure regulating type valves shall be installed on pump discharge as shown on the drawings. Pressure shall be set according to the table below. Valve shall be suitable for the chemical solution service specified. The valve body shall be PVC, and the diaphragm shall be PTFE faced EPDM.

Valve number	Service	Valve size, inches	Maximum flow, gpm	Inlet pressure range, psig	Outlet pressure, psig
TBD					
TBD					
TBD					
TBD					
TBD					

   2. Adjustable pressure relief type valves shall be installed on pump discharge as shown the drawings. Pressure shall be set according to the table below. The valves shall be sized to handle a maximum flow through the valves of not less than 1.5 times the maximum flow supplied by the associated pump. The valve shall be suitable for the chemical solution service specified. The valve body shall be [PVC], and the diaphragm shall be [PTFE faced EPDM].

Valve number	Service	Valve size, inches	Pressure Relief, psig
TBD			
TBD			
TBD			
TBD			
TBD			
TBD			

2.05 DRIVE UNITS AND CONTROLS

A. Adjustable Speed Drive:

1. Pumps shall be provided with an integrally mounted adjustable speed drive. The speed setting of the drive shall be continuously adjustable over a minimum 110:1 operating range. The adjustable speed drive shall be for use with brush motors, and be located in a NEMA 4X cabinet. Drive shall be supplied with one 120 VAC input. Drive motor shall be servo permanent magnet DC with integral gear box.

B. Motors:

1. Drive shall be rated for continuous 24-hour operation. Pumps shall have non-maintained maximum speed switches for purpose of priming. Pump drives shall be close coupled and self aligning, requiring no flexible couplings. Each pump shall be capable of operating with a range of hose/tubing diameters and thicknesses which may vary depending on the drive size of the pump.
2. The drive enclosure shall be NEMA 4X rated and be factory coated with a corrosion resistant non-reactive (e.g. polyester and/or polyurethane) coating. Drive motors shall be integrally mounted in drive enclosure.

C. Local Controls:

1. Local controls (confirm these are on the pump) shall consist of a speed adjusting potentiometer, a START pushbutton, a STOP pushbutton, and an AUTO/MANUAL switch. Control shall be such that when the drive is running in the MANUAL mode, speed shall be adjusted with the local potentiometer. In the AUTO mode, the drive shall operate in response to an external run command and 4-20 mA external speed reference signal as shown on drawings.
2. NEMA 4X rated controls shall be provided on the pumps. The controls shall provide as a minimum the following features:
    a. Accept a 4-20 mA speed reference input signal
    b. Accept dry REMOTE-RUN contact
    c. Provide a 4-20 mA drive speed output signal
    d. Provide dry contacts rated for 1 amp at 120 VAC for the following status:
        1) Running
        2) In AUTO mode
        3) In MANUAL mode
        4) Pump leaking (Confirm this signal is required to PLC)
    e. Leak Detection

1) If a pump leak is detected, the pump will be disabled and a standby pump will be enabled.

3. Provide the following instruments and appurtenances which comply with the respective Division 40 specifications:
   a. Pressure transmitters
   b. Pressure gauges
   c. Magnetic flow meters

2.06 EQUIPMENT MOUNTING

A. Pumps shall be suitable for installation on a wall-mounted structural support.

2.07 ACCESSORIES

A. Flow Calibration Columns:
   1. Pumps shall be provided with flow calibration columns on the pump suction lines. Calibration columns shall be manufactured of clear PVC, and shall be labeled in standard divisions and milliliters. Calibration columns shall have a volume of 1/2 liter and shall have 1/2-inch female NPT connections at the top and bottom. Calibration chambers shall be provided by the same manufacturer as is furnishing the pumps.

B. Leak Detection:
   1. Pumps shall be provided with leak detection located on the tube which shall interconnect to the pump control panel. The control panel shall provide a dry contact alarm for remote indication of leak detection.

C. Flow Measurement:
   1. Pumps shall be provided with a magnetic flow meters on the pump discharges. The flow meters shall be configured to signal both flow and no flow conditions.

2.08 COATINGS

A. Except as otherwise specified in this Section 46 33 44, equipment shall be shop primed in accordance with the requirements of Section 09 90 00.

2.09 SPARE PARTS

A. The following spare parts components shall be provided:
   1. Ten lengths of tubing in each size (diameter) as necessary to satisfy the requirements of paragraph 1.01 Design Requirements.
   2. One pump head for each size pump.

B. Spare parts shall be tagged and stored as specified in Section 43 05 11.

2.10 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:
   1. Operation and maintenance data, as specified in Section 01 78 23, on the pumps, adjustable speed drives and accessories.

2. Manufacturer's certification (Form 43 05 11-A per Section 01 99 90) that the equipment has been properly installed, aligned and tested and meets all requirements for satisfactory performance under the conditions specified.
3. Manufacturer's instruction certification (Form 43 05 11-B per Section 01 99 90) that instructions to operators have been completed.
4. Motor data as specified in Section 43 05 21.
5. Pump Test Log as specified in paragraph 3.03.

PART 3 EXECUTION

3.01 GENERAL

A. Pumps shall be aligned, connected, and installed in strict accordance with the manufacturer's instructions.

3.02 INSTALLATION

A. The equipment shall be installed and tested under the direction of factory trained personnel as specified in Section 43 05 11. The installation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.03 TESTING

A. After installation, the equipment specified in this section shall be completely tested to ensure compliance with operating requirements, varying pumps speeds with speeds and flows recorded in a test log. Field testing shall be in accordance with the testing procedures in Section 01 45 20. Testing shall verify the control strategies specified in Division 40.

B. Following successful testing and commissioning of associated control loops, and prior to pumping chemical solution, the pump and chemical piping shall be emptied and dried. See Section 40 05 01 for additional requirements.

3.04 TRAINING

A. A minimum of 6 hours of training, as specified in Section 01 79 00, shall be provided. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

END OF SECTION

SECTION 46 41 17

CHEMICAL INJECTORS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the general requirements for design, selection, and supply of chemical injectors. Installation, inspection, and testing are also specified in this Section.

B. Equipment List

Item	Equipment Number	Supplied by
SH Raw Water Pipe Feed Injector	IQXXXXX	CONTRACTOR
SH Combine Filter Outlet Feed Injector	IQXXXXX	CONTRACTOR
SH Backwash Pipe Feed Injector	IQXXXXX	CONTRACTOR

C. The Contractor shall be responsible for providing injectors injected in line as shown in the Drawings.

D. Chemical Service:

1. The equipment shall be designed and selected for handling the following chemical solution[s]:

Chemical	Abbreviation	Concentration (wt/wt)
Sodium Hypochlorite	NaOCl	5.37%

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 33 00 – Submittal Procedures
2. Section 01 45 23 – Testing and Inspection Services
3. Section 01 78 23 – Operation and Maintenace Data
4. Section 01 78 39 – Project Record Documents
5. Section 40 05 02 – Piping System Schedules
6. Section 40 05 45 – Piping System Identification

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ASME B16.21	Nonmetallic Flat Gaskets for Pipe Flanges

Reference	Title
ASME B31.1	Power Piping
ASME B31.3	Process Piping
NSF 61	Drinking Water Components – Health Effects

1.04 SUBMITTALS

A. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The City shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has ben received and found to be in conformance with these requirements.

C. Manufacturer's data confirming piping connections, locations, and sizes.

D. Injector sizing curves and information confirming size and selection of injectors.

1.05 QUALITY ASSURANCE

A. Review the drawings prior to installation of equipment. Coordinate the length of the mixers with available space for installation.

B. See Section 01 45 23 for additional inspection requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 INJECTION ASSEMBLIES:

A. Provide injection assemblies where shown on the Drawings and specified herein.

B. Requirements:

1. Injection quills shall be threaded into the side of the process pipe or mixer at the locations specified with 1/2-in or 3/4-in NPT fitting.
2. Components shall include a spring-loaded ball check valve, retractable solution tube (injector), solution tube body, compression gland, ball valve, dual limit chains and dual bolt restraints.
3. Tip profile of the injection tube shall be standard/flat except for sodium hydroxide quills which shall include elastomeric duckbill tips.
4. Coordinate injector tube insertion length with the static mixer manufacturer where applicable to insure against interferences with the mixer port and/or mixing plate and to insure the chemical is injected in the centerline of the process pipe.
5. Injection quills shall be installed at each location identified in the table below and shall be constructed with materials compatible with each chemical. Injection quills shall be able to withstand maximum pump discharge line pressure and water main pressure as specified in applicable pipe schedules under Section 40.
6. Injection assemblies shall be as manufactured by Saf-T-Flo or equal.

Equipment Number	Process Pipe Diameter, inches	Chemical Inlet Size, inches	Process Tap Size, inches	Water Flowrate, MGD		Chemical Details			Wetted Materials
				Maximum	Minimum	Chemical	Maximum Flowrate, gph	Minimum Flowrate, gph	
IQXXXXX	36	1/2	1	17.6	2	Sodium Hypochlorite	37.9	0.7	CPVC or Hastelloy C276
IQXXXXX	36	1/2	1	17.6	2	Sodium Hypochlorite	37.9	0.7	CPVC or Hastelloy C276
IQXXXXX	24	1/2	1	17.6	2	Sodium Hypochlorite	28.5	0.7	CPVC or Hastelloy C276

PART 3 EXECUTION

3.01 GENERAL

A. The equipment shall be installed in strict accordance with the applicable sections of Division 1 and the respective manufacturer's instructions and recommendations.

3.02 INSTALLATION

A. The equipment shall be installed and tested under the direction of factory trained personnel as specified in Section 43 05 11. The installation shall be certified on Form 43 05 11-A specified in Section 01999.

3.03 TESTING

A. After installation, the equipment specified in this section shall be completely tested to ensure compliance with operating requirements and flows recorded in a test log.

END OF SECTION

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SECTION 46 41 42

FLOCCULATOR MIXERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies mixing equipment for the City Creek Water Treatment Plant flocculation tanks. The mixers shall be a complete assembly with electric motor, gear reducer, mechanical seal, shafts, impeller, and all specified appurtenances, mounted on a common pedestal base. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the mixer manufacturer for the equipment specified in this Section.
2. Each mixer will be driven by a variable speed drive provided under Section 26 29 23 and supplied by the Contractor. The mixer manufacturer shall submit a letter of confirmation on the suitability for use of the Contractor's proposed VFD selection.
3. Flocculation tanks are configured with 2 basins, each having 3 stages, for a total of 12 flocculators for the project. The flow enters the first stage near the bottom and passes from the first stage over a baffle to the second stage, then under a baffle from the second to third stage, and ultimately over a baffle from the third stage flows into a common flocculated water distribution channel.

B. Equipment List:

1. The following is the list of equipment which is specified in this section. The location of each piece of equipment is shown on the drawings.

Equipment Name	Mixer Number
Flocculator 1A	30-MX-11010
Flocculator 2A	30-MX-12010
Flocculator 3A	30-MX-13010
Flocculator 1B	30-MX-11020
Flocculator 2B	30-MX-12020
Flocculator 3B	30-MX-13020
Flocculator 4A	30-MX-21010
Flocculator 5A	30-MX-22010
Flocculator 6A	30-MX-23010
Flocculator 4B	30-MX-21020
Flocculator 5B	30-MX-22020
Flocculator 6B	30-MX-23020

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 26 29 23 Variable Frequency Motor Controllers
2. Section 43 05 11 General Requirements for Equipment
3. Section 43 05 13 Rigid Equipment Mounts
4. Section 43 05 21 Common Motor Requirements for Equipment

1.03 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section, as specified and modified. In case of a conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AFBMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
AFBMA Std 11	Load and Fatigue Life for Roller Bearings
AGMA 250.04	Lubrication of Industrial Enclosed Drives
AGMA 297.02	Sound for Enclosed Helical, Herringbone, and Spiral Bevel Gear Drives
AGMA 390.03a	Gear Classification, Materials, and Measuring Methods for Bevel, Hypoid, Fine Pitch Worm Gearing and Racks Only as Unassembled Gears
AGMA 6010-E	Spur, Helical, Herringbone, and Bevel Enclosed Drives
AGMA 9002-A	Bores and Keyways for Flexible Couplings
ANSI/AGMA 2101-C95	Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
DIN 3962	Tolerances for Cylindrical Gear Teeth
DIN 3990	Calculation of Load Capacity of Cylindrical Gears
EN 50262	Metric Threads of Cable Glands
EN 50347	Standardized Dimensions and Power Ranges
IEC 60034-1, EN 60034-1	Rotating Electrical Machinery, Rating and Performance
IEC 60034-2-1, EN 60034-2-1	Rotating Electrical Machines, Determining Losses and Efficiency
IEC 60034-5, EN 60034-5, EN-60529,	IP Degrees of Protection for Enclosures
IEC 60034-9, EN 60034-9	Rotating Electrical Machines, Noise Limits
IEC 60034-14, EN 60034-14	Rotating Electrical Machines, Vibration Levels
IEC 60034-30	Rotating Electrical Machines, Classification of Efficiency Levels IE1, IE2, IE3
IEC 60072	Dimensions and Performance of Rotating Electrical Machinery
NEMA	MGI Efficiency Tables

B. Manufacturer's Experience:
   1. The mixers shall be a product of a manufacturer experienced in the design and fabrication of equipment of this type. Manufacturer shall have experience with design and supply of vertical mixers of the type specified and demonstrate a minimum of 10 installations in the US in similar applications in successful operation for a minimum of 5 years.
   2. Mixer manufacturer must have in-house CFD modeling capabilities with a CFD model that has been verified by physical modeling.

C. Factory Testing:
   1. Manufacturer shall provide the following factory testing:
      a. A visual inspection of the unit to confirm project requirements.
      b. The unit shall be run partially loaded at maximum speed for at least 2 hours after its oil temperature has stabilized. During this period, sound levels shall be measured at a distance of 3 feet away from the unit and recorded in accordance with AGMA 297.02. Regardless of gear speed, sound level shall not exceed 85 dBA. During the test period, the unit shall be monitored for oil leaks, excessive lubricant temperature, and excessive vibration. Any causes for leaks, excessive sound, vibration, or lubricant temperature shall be corrected before shipment. Near the end of the test, a suitable gear marking compound shall be added to the oil. Following the test run, oil shall be drained, inspection covers removed, and gear teeth shall be inspected for proper contact.
      c. Measurement of the no load amp draw of the motor.
      d. Measurement of the output speed to verify gear ratios.
   2. The manufacturer shall provide a brief letter report certifying that the unit has passed the specified test and inspection requirements. The entire assembly shall be prepared for shipment in accordance with the manufacturer's recommendations.

D. Unit Responsibility:
   1. The Contractor assigns unit responsibility as specified in Section 43 05 11 to the manufacturer of the mixers provided under this section. This manufacturer is the unit responsibility manufacturer and has unit responsibility, as specified in Section 43 05 11 for both the equipment assembly specified in this section and for the motors as specified in Section 43 05 21 and all other equipment assembly components specified elsewhere but referenced in this section. A completed, signed, and notarized Certificate of Unit Responsibility (Section 01 99 90-Form 43 05 11-C) shall be provided.

E. Shipment and Storage:
   1. The equipment shall be protected during shipment and storage as specified in Section 01 66 00 and in accordance with manufacturer’s instruction. No sudden temperature fluctuations, aggressive vapors, or shocks shall be allowed.

1.04 ENVIRONMENTAL CONDITIONS

A. Mixers specified in this section will be installed indoors.

1.05 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
    a. Section 43 05 11 – General Requirements for Equipment
    b. Section 43 05 13 – Rigid Equipment Mounts
    c. Section 43 05 21 – Common Motor Requirements for Equipment
3. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Supplier/Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Supplier/Subcontractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Unit Responsibility Certification form (Form 43 05 11-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.
6. Manufacturer's product literature and shop drawings, including submergence requirements for the impeller, dimensioned drawings of mixer layout, anchorage and base details, blade diameter and details, shaft diameter and speed, and materials of construction.
7. Flocculator performance data to include relationship between speed (rpm) and mixing intensity (G-value, sec-1) at a minimum of ten points including maximum and minimum speed.
8. Mixer weights and loads transmitted to the supporting structure.
9. Manufacturer's experience statement as specified in paragraph 1.03 B.1.
10. Statement by the manufacturer indicating that gears comply with AGMA standards, and bearings comply with AFBMA standards specified in this section.
11. Motor product data as specified in Section 43 05 21.
12. Manufacturer’s operation and maintenance information in accordance with Section 01 78 23.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Equipment anchor calculations.
   3. O&M information specified in Section 01 78 23.
   4. Bearing L-10 life calculations.
   5. Letter of confirmation of suitability of variable frequency drives being provided by the Contractor for this equipment in accordance with Section 26 29 23. Letter shall be on manufacturer's letterhead.
   6. Calculations of the mean velocity gradient during operation and the operating speed to first critical speed ratio. Calculations shall be stamped by a professional engineer registered in one of the fifty (50) United States.
   7. Installation instructions.
   8. Testing and adjusting instructions.
   9. Installation certifications per Part 3.01 and 3.02, certifying equipment is installed and tested properly and ready for service.
   10. Testing Forms in accordance with Section 01 99 90 and including shop test report per Part 1.03.C.2.
   11. Installation Forms in accordance with Section 43 05 11.
   12. Operation and maintenance information per Section 01 78 23.
   13. Training plan.

C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 01 78 23.
   2. Provide the following Spare parts: Provide a breakdown of replacement cost along with a listing of spare parts within the shop drawing submittal.
      a. One set of bearings, shims, and seals for each size of gear reducer,
      b. One flexible coupling,
      c. Any additional spare parts as recommended by the manufacturer.
   3. Spare parts shall be tagged and stored in compliance with Section 43 05 11.

1.06 WARRANTY

A. Warranty shall be for a period of 1 year from date of substantial completion, unless standard warranty is for a longer term. Provide the longer of 1 year, or standard warranty.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be protected during shipping and storage prior to installation in accordance with Section 01 66 00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The mixers shall be by SPX Flow/Lightnin , Philadelphia Mixers, or approved equal.

2.02 TYPE

A. Mixers shall consist of an electric motor, high-speed flexible coupling, bearing housing, impeller shaft, mechanical seal, and impellers. Impeller shafts shall be of the overhung design. Underwater guides or bearings will not be accepted.

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:

1. The equipment shall be designed and selected for continuous mixing of the rapid mix effluent to provide flocculation. The maximum flow through each basin is expected to 8.8 mgd through each basin, with range in temperatures between 55 degrees F and 85 degrees F, and the pH may vary between approximately 6 and 8.

B. Operating Conditions:

1. The mixers shall be suitable for operation in the flocculator tanks and designed for continuous duty under the specified conditions. The mixer shall provide gentle mixing to encourage particle collisions and floc development while minimizing the floc breakup through over-mixing.
2. The mixers shall be designed for the tank dimensions and water surface elevations as shown in the table below. Each mixer shall operate independently and shall be controlled from the local control panel or PLC provided by others. The mixers shall be variable speed.
3. The nominal flocculation detention time with all trains in service is 41 minutes.
4. Required performance shall be met with one train out of service or with all in service across the range of flows specified above.

Schedule of Service Conditions

Design Parameter	Flocculator Mixers Stage 1 30-MX-11010 30-MX-11020 30-MX-21010 30-MX-21020	Flocculator Mixers Stage 2 30-MX-12010 30-MX-12020 30-MX-22010 30-MX-22020	Flocculator Mixers Stage 3 30-MX-13010 30-MX-13020 30-MX-23010 30-MX-23020
Area Dimensions for Flocculator: Length x Width, ft	18.5 x 20	18.5 x 20	18.5 x 20
Average Side Water Depth, ft	15	15	15
Top of Platform Elevation	5336.67	5336.67	5336.67
Impeller Diameter, inches	104	104	104
Min. Impeller Shaft Diameter, inches	2.0	2.0	2.0
Direction of Pumping	Down | Clockwise	Down | Clockwise	Down | Clockwise
Min. mean velocity gradient, s^{-1}	35	25	25
Max. mean velocity gradient, s^{-1}	70	40	40
Maximum rated motor power, HP	3	2	2

Notes:

1. Velocity gradient values at minimum water temperature of 2 deg C.
2. Concrete base, grout, and mounting design may increase the actual mixer elevation. Confirm exact elevations with the manufacturer prior to shaft fabrication.

2.04 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Shaft	Type 316 Stainless Steel
Impeller	Type 316 Stainless Steel
Miscellaneous wetted parts	Type 316 Stainless Steel
Anchor Bolts, Nuts, Washers, Fasteners	Type 316 Stainless Steel

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Supplier/Subcontractor may propose alternate materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.05 EQUIPMENT FEATURES

A. General

1. The mixer shall consist of a heavy-duty gear speed reducer, drive motor, support members, shaft, and hydrofoil turbine impeller. Each drive shall have a horizontal input shaft and vertically downward output shaft. Outline dimensions and anchor bolt pattern shall be compatible with the installation conditions specified.
2. Drive motor will be controlled by an electrical variable frequency drive (VFD). VFDs are to be supplied by the Contractor and be as specified in Section 26 29 23, Variable Frequency Motor Controllers.

3. All motor and gearbox assemblies shall have lifting lugs.
4. Sound level shall not exceed 85 dBA at a distance of three feet from the drive assembly at any operating speed.
5. Design equipment for 365-day, 24-hours per day continuous operation.
6. Gear reducer assemblies and devices mounted on, at or near the assemblies shall be suitable for an outdoor environment at the location of the facility.
7. Design flocculator assemblies to run at any operating speed at any liquid level in the basin, including empty, without mechanical damage.

B. Gear reducers
1. Construction: Provide right angle gear reducer in accordance with AGMA Standards.
2. Nameplate: Provide stainless steel nameplate with AGMA calculated drive horsepower rating.
3. Efficiency: Gear drive train efficiency shall not be less than 95 percent.
4. Cooling: External cooling coils or devices to dissipate heat will not be acceptable.
5. Openings: Provide water and dust proof covers.
6. Internal Output Shaft Diameter: Equal to or greater than the impeller shaft diameter.
7. Gear reducer configuration shall be selected to provide the smallest footprint available above deck.
8. Rating:
   a. Gear reducers which include separate shaft bearings, located above and below the main drive bearings and a torsionally resilient coupling at the impeller shaft, shall have a minimum rating of 1.5 times the rated horsepower of the drive motor.
   b. Gear reducers which incorporate bearing arrangements other than that described above, shall have a minimum rating of 2.0 times the rated horsepower of the drive motor.
9. Lubrication:
   a. Provide easy filling and draining without spills.
   b. Provide dry well construction designed to eliminate lubricant leakage at the output shaft.
   c. Provide splash or immersion lubrication from a common sump for all gearing.
   d. Provide a dip stick to observe lubricant level.
   e. Output shaft bearings may be grease lubricated. All other bearings shall be submerged in the lubricant. Inlet and outlet grease fittings shall be accessible from outside the gear reducer housing. Provide neoprene covers over fittings.
   f. Each gearbox shall be supplied with a food grade lubricant meeting NSF 60 certification. The lubricant shall be as specified by the manufacturer for compatibility and warranty specifications.
10. Bearings:
   a. All bearings within the reducer shall be of the antifriction ball or roller type.

b. All bearings other than those in the impeller shaft system shall have a minimum AFBMA L-10 life of 100,000 hours when operating continuously at the full rated load motor horsepower and speed. Output impeller-shaft bearings shall each have a minimum AFBMA L-10 life of 300,000 hours under the same full-load conditions. Bearings shall be splash oil lubricated or grease lubricated. All grease lubricated bearings shall have seals to prevent leakage.

11. Gears and Gearing:
    a. General: Gear reducer assembly shall incorporate a double or triple reduction gear drive system.
    b. Type: Gearing shall be a combination of helical and spiral bevel. Worm gearing is not acceptable.
    c. Gear Quality: gearing shall be AGMA Quality No. 10 or better in accordance with AGMA 390.03, with bevels being AGMA Quality No. 8 or better.
    d. Arrangement: Output shaft shall pass through a hollow shaft driven by the gear train.
    e. Gear Ratios: Not to exceed 7 to 1.
12. Gear Reducer Housing:
    a. Materials: Close grained cast-iron, ductile iron or stress relieved fabricated steel.
    b. Accessories: Provide lifting lugs.
    c. Openings: Provide water and dustproof covers and seals over all openings.

C. Impeller shaft
1. Provide overhung solid shaft design. The shaft shall be centerless ground and finished for straightness and cleanliness. The material of construction shall be as specified herein.
2. Bearings located outside of the gear reducer are not permitted.
3. Connect impeller shaft to the output shaft of the gear reducer by means of a rigid coupling located above the mounting platform. The rigid coupling halves shall be machined with a rabbet for concentricity. Safety guards for rigid couplings shall be provided. Provide for removal (dropping) of the shaft without disturbing the gear reducer housing or any internal components.
4. The shaft-impeller system shall be safe for operation when: the liquid level rises through the impeller while the mixer is operating; during deceleration and acceleration associated with a momentary power outage; and with unbalanced process flows that may be perpendicular to the shaft-impeller system. The entire system shall be hydraulically and dynamically stable during fluctuations in water levels commonly associated with turbulent mixing and with variations in process flow.
5. Combined Tensile and Shear Stress: Not to exceed 8,000 psi at maximum load.
6. Runout: Not to exceed 1/4-inch for every ten feet of overhang as measured when turning by hand.
7. Couplings: Use rigid flanged bolted type couplings connected to the shafts by welding. Mating faces shall utilize a rabbeted male and female connection and shall not require match marks for alignment. Use same materials as specified for the shafts. Mixer shaft shall attach to reducer by split removable coupling located above mounting surface.
8. Critical Speed: Maximum output shaft speed shall not exceed 70 percent of the first lateral critical speed.

9. Length: Not to exceed 20 feet per section. Provide an additional impeller shaft coupling located below the mounting platform and above the water level, if necessary to limit the length of shaft.
10. Keyway: Provide for field adjustment of the impeller setting of not less than 9-inches above and below the setting in 3-inch or less increments.

D. Impeller:
1. Provide a single, low-speed, field removable, hydrofoil type impeller specially designed to minimize shear and turbulence while maximizing fluid motion. Provide up or down pumping impellers as required in the Schedule of Service Conditions. Key the impeller to the shaft.
2. Tip speed: Provide as required for optimum performance, but not to exceed 8 ft/s at a G-value of 80 s^{-1}.
3. Setting: Locate the centerline of the impeller from the basin bottom as shown in the Contract Drawings.
4. Combined Tensile and Shear Stress: Not to exceed 11,000 psi under maximum loading conditions.

E. Mounting:
1. General: Provide as required to mount the gear reducer frame with pedestal to the support pad to elevate the low speed coupling and oil drain above the mounting floor elevation.
2. Type:
   a. Adhesive anchors for mounting in accordance with the details shown and sufficient to withstand the torque and other loadings transmitted by the gear reducer. Conform to the requirements of Section 05 05 20.
3. The anchor bolts shall be sized by the manufacturer.

F. Motor
1. Suitability: Suitable for the torque load, variations in torque and other loading conditions imposed by the gear reducer and also suitable for the variable speed drive controller. Gear motors are unacceptable.
2. Ratings:
   a. Nameplate horsepower rating and allowable temperature rise shall not be exceeded under any specified loading condition at any operating speed.
   b. Motors shall not be rated at less than 1.0 horsepower, nor less than the rating shown in the Schedule of Service Conditions.
3. Speed:
   a. Maximum: 1,800 rpm.
   b. Minimum: 900 rpm.
4. Enclosure: Type 2 per Section 43 05 21, TEFC with finned cast housing.
5. Applicable Standards: IEEE, NEMA, ABMA and ANSI.
6. Gear Reducer Connection: Provide an easily accessible torsionally resilient flexible coupling between the motor and the gear reducer. Provide a coupling guard.
7. Insulation: Class F or better.
8. Temperature Rise: Limit to Class B temperature rise at 40°C ambient at full load.

9. Nameplate: Provide a stainless steel nameplate describing motor characteristics and required lubricants.
10. Motors shall conform to the requirements of Section 43 05 21.

2.06 TOOLS AND SPARE PARTS

A. Special tools:
   1. Special tools, if required for normal operation and maintenance, shall be furnished with the equipment.

B. Spare parts:
   1. The following spare parts shall be provided for each size mixer:
      a. One set of bearings, shims, and seals
      b. One flexible coupling
      c. Any additional spare parts as recommended by the manufacturer
   2. Spare parts shall be tagged and stored as specified in Section 43 05 11.

2.07 COATINGS

A. Stainless steel components shall be provided with an ASTM A480, No. 2B finish. Ferrous or steel components shall be factory coated per Section 09 90 00.

PART 3 EXECUTION

3.01 INSTALLATION

A. The mixers shall be installed as specified and in accordance with the manufacturer's written recommendations. The installation and initial operation shall be certified in writing by the Supplier/Subcontractor. Installation shall be carried out by mechanics skilled in work of this kind, under the general supervision of a factory-trained representative of the manufacturer. Total shaft runout and deflection shall be checked by hand turning the shaft. Maximum shaft runout or deflection shall not exceed 1/4-inch per 10 feet of shaft length at any point along the shaft. The equipment shall be checked, aligned, tested, and placed in operation by a factory-trained manufacturer's representative.

3.02 FIELD QUALITY CONTROL AND TESTING

A. After installation and prior to being placed in operation, each unit shall be inspected and checked by a qualified representative of the equipment manufacturer, as required.

B. The Contractor shall make all adjustments to each unit as directed by Supplier/Subcontractor prior to placing the unit in operation. Each mixer shall be checked by the manufacturer for lubrication, alignment, rotation and the representative shall notify the Contractor of anything in the installation which affects the manufacturer's warranty. The manufacturer's representative shall provide certification that each mixer is rotating in the right direction and is ready for testing.

C. After completion of the installation, the equipment shall be field tested as specified in Section 01 45 20 to demonstrate compliance with the specified performance requirements. Equipment supplier to provide within their price all labor and effort to support Pre-operational check out, Functional Testing, and Start-Up Testing as specified in Section 01 45 20.

D. As part of the Functional Test, a factory trained representative shall test the installed equipment at full load and full speed for a minimum of 4 hours after oil temperature has stabilized. The test runs of the mixers shall be undertaken with water in the tanks filled up to the peak water elevations. The test runs on the mixers shall determine acceptable running noise, speed and rotational direction. The reducer housing and shaft seals shall be checked for leaks during the test. Any leaks shall be corrected and the test repeated at the Supplier/Subcontractor 's expense. Oil temperature shall be recorded at intervals of no greater than 15 minutes and shall not exceed the manufacturer's recommended maximum. Sound level shall be recorded and shall not exceed 85 dBA at a distance of 3 feet from the equipment. Provide a written certification from the equipment manufacturer that the equipment has been properly installed according to the plans, specifications and manufacturer's specifications, and that the equipment is operating normally. In the event of improper installation, correction of the work and subsequent test runs will be provided until the defects are corrected at no additional cost to the Contractor. Manufacturer shall provide certification that the improper installation has been corrected.

3.03 TRAINING

A. Training shall be provided as specified in 01 79 00. A minimum of eight (8) hours of total training shall be provided and comprised of the following:
   1. Operations Training: Two (2) sessions, two (2) hours per session.
   2. Maintenance Training: Two (2) sessions, two (2) hours per session.

B. Upon completion of the training activities, the Manufacturer shall provide an executed Instruction Certification Form 43 05 11-B.

C. The Supplier/Subcontractor's representative shall provide one additional (4-hour) day on-site as part of a separate trip at the time of start-up to provide startup support and furnish additional training of the Owner's personnel in the operation and maintenance of the equipment.

END OF SECTION

SECTION 46 43 21

CIRCULAR CLARIFIER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies sludge collection equipment for circular clarifiers in the use of gravity separation of solids from flocculator basin effluent.

B. Scope: This section specifies clarifier equipment as follows:
   1. Sludge collection equipment
   2. Drive equipment
   3. Walkways and access bridges with guardrails and grating to the drive equipment
   4. Miscellaneous appurtenances as shown and specified herein

C. Type: Equipment furnished under this Section shall be suitable for installation in circular tanks. The equipment shall be specifically design for the conditions described and shown.

D. Equipment List:

Item	Equipment Number
Primary Clarifier 1 Mechanism	60-CL-0013

1.02 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Continuous operating torque: The continuous operating torque is defined as the 100% AGMA design torque which is the torque load that is assumed to be continuously applied on the drive system through a 24-hour operating period, 365 days per year for a 20-year life. Bearing life, gear strength, gear durability, gear rating, mechanism structural design, and alarm and shutdown setpoints are specified as a percentage of the continuous operating torque.
   2. Alarm Torque: The torque at which an alarm sounds to serve as a warning of increased torque loading. The alarm torque is defined to be equal to 110 percent of the continuous operating torque.
   3. Cutout Torque: The torque load at which a motor cutout switch is activated to shut down the unit. The cutout torque is defined to be not less than 120 percent of the continuous operating design torque.
   4. Momentary Peak Torque: The maximum or peak torque of the drive unit assumed to be equal to twice the calculated AGMA torque rating of the spur gear set or 3 times the calculated AGMA torque rating of the worm gear set, whichever is lower.

1.03 QUALITY ASSURANCE

A. Reference Standards:

1. This section contains references to the following documents. They are part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ABMA-9	Load Ratings and Fatigue Life for Ball Bearings
AGMA 2001-B	Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
AGMA 6013	Standard for Industrial Enclosed Drives
AGMA 6010-E	Standard for Spur, Herringbone, and Bevel Enclosed Drives
AGMA 6019-E	Gearmotors Using Spur, Helical, Herringbone, Straight Bevel or Spiral Bevel Gears
AGMA 6034-B	Enclosed Cylindrical Worm Gear Speed Reducers and Gear Motors
AISC	American Institute of Steel Construction, Steel Construction Manual, 16th Ed.
AISI	Pocketbook of AISI Standard Steels
ASTM A36/A36M	Structural Steel
ASTM A48-REV A	Gray Iron Castings
ASTM A536	Ductile Iron Castings
ASTM A666	Austenitic stainless steel, sheet, strip, plate and flat bar for structural application
ASTM B247	Aluminum-Alloy Die Forgings, Hand Forgings and Rolled Ring Forgings
ASTM E18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
AWS D1.1	Structural Welding Code—Steel
AWS D1.6	Structural Welding Code—Stainless Steel
NEMA 250	Enclosures for Electrical Equipment

B. Standards:

1. Structural Steel and Welds:
   a. All structural steel used for equipment fabrication shall conform to the requirements of the Standard Specifications for Steel for Bridges and Buildings. All welding shall conform to the latest standards of the American Welding Society (AWS). Continuous seal welds shall be provided at all welded joints. Skip welds will not be permitted.

2. Structural Design:
    a. All steel structural components shall be so designed that the stresses developed under the specified conditions will not exceed the allowable stresses defined by the AISC standards and the aforementioned standards. Except where specifically indicated otherwise, all plate and structural members designed for submerged service shall be steel with a minimum thickness of 1/4 inch. AISC recommended limits for slenderness shall not be exceeded on any steel member.

C. Unit Responsibility:
    1. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the circular clarifier equipment manufacturer for the equipment specified in this section, the drive motors, and all other appurtenances required to operate the equipment. Provide a completed and signed Unit Responsibility Certification Form (Form 43 05 11-C, Section 01 99 90).

1.04 SUBMITTALS

A. Procedures: Section 01 33 00

B. Action Submittals:
    1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance of the part of the Contractor with the specifications. Failure to include a copy of the marked up specification sections, along with justification(s) of any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
    2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
    3. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
    4. General arrangement drawings showing the entire assembly. This shall include a materials list and descriptions of all major components such as all gears, structural members, and sludge collection members (sizes, piping, connections, ASTM designations where appropriate, thicknesses, and construction).

5. Rating, AGMA and ASTM designations, construction, and detailed descriptions of all gears, reducers, and drives.
6. Calculations substantiating the torque rating of the gear assembly as specified herein.
7. Bearing manufacturer, bearing model, and ABMA L-10 life data.
8. Concrete anchors for clarifier mechanism, bridge, and other necessary equipment.
9. Proposed on-site testing and start-up procedures, including sketches and calculations for torque test as specified herein.
10. Motor submittal requirements of Section 43 05 21.

C. Informational Submittals:
1. Calculations, stamped by an engineer registered in the State of Utah, that demonstrate support and anchor bolt (i.e. number, diameter, length) design complies with the requirements of this Section.
2. Calculations showing stresses in the drive cage, sludge collection arms and walkways as specified in paragraph 2.03 Drive Cage, paragraph 2.03 Sludge Collector Mechanism and paragraph 2.03 Walkway and Operating Platform
3. Calculations sizing the sludge scraper blades for uniform sludge withdrawal and other data specified in paragraph 1.05.
4. Manufacturer's operation and maintenance information in accordance with Section 01 78 23 including:
   a. Copy of final reviewed submittal.
5. Testing Form in accordance with Section 01 45 20.
6. Installation Certification Form 43 05 11-A as specified in paragraph 3.01.
7. Training Certification Form 43 05 11-B as specified in paragraph 3.02.
8. Form 43 05 13-A, Rigid Equipment Mount Installation Checklist in Section 01 99 90.

1.05 PERFORMANCE AND DESIGN REQUIREMENTS:

A. All structural members shall be designed in accordance with AISC standards and shall be capable of transmitting the momentary peak torque without undue or permanent deflection. AISC recommended slenderness limits shall not be exceeded for the design of all members. In addition to the specified operating loads, each member shall be designed to withstand a point load of 200 pounds applied perpendicular to its weak axis at the midpoint between its support areas.

B. The sludge collector mechanism includes a central driving mechanism mounted on a center support pier, to support and rotate a center cage with 2 truss arms.

C. Sludge accumulated in the clarifier is scraped to a center well for intermittent/continuous removal. Sludge is transported in a single revolution toward a center sludge hopper. Sludge removal is accomplished by operation of the drain valve.

D. The central pier and column assembly shall be designed to support the drive mechanism, the sludge collection mechanism, utility piping, access bridge beams and walkway. No vertical thrust load shall be placed on any underwater bearing. All drive gears shall be located above water level and all gearing shall be completely enclosed and oil-lubricated. The drive cage, each sludge collector arm, and associated supports and connecting members shall be designed to withstand application of 200 percent of the continuous operating torque at the AISC allowable stresses. The drive cages shall be designed to withstand these forces resulting from operation in the clockwise and counter-clockwise directions.

E. The access bridge and operating platform shall be design for a live load of 100 pounds per square foot. Deflection under full live load and dead load shall not exceed 1/360 of the span.

F. Operating Conditions: The equipment shall be designed and operable for the following conditions for each clarifier:

Parameter	Minimum	Maximum
Influent Flow, mgd	1.5	15.2
Liquid Depth, ft	0	15.0

G. Design Requirements: Tank configuration is specified as follows:

Item	Clarifier
Internal tank diameter, feet	60'-0"
Sidewater depth, feet	+/- 15
Depth at center column, feet	17 ft, 6 inch
Floor Slope	1: 12
Center column minimum diameter, inches	18
Sludge collection arms, number	2
Collector mechanism rotating speed, ft/min	11.8
Continuous operating torque, ft • lbs, applied at the output of drive unit	13,500
Nominal bearing race diameter, inches	35
Maximum Motor output, horsepower	1.0

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers and models are listed below. To conform with specified requirements, the manufacturer's standard product may require modification.
   1. Ovivo Clarifier Mechanism
   2. WesTech Engineering, Inc.
   3. Evoqua
   4. Walker Process
   5. ClearStream

B. Candidate manufacturers shall have a minimum of 20 years' experience designing clarifier equipment.

2.02 MATERIALS

A. Materials of construction:

Component	Material
Center column	ASTM A36 carbon steel ANSI,
Steel plate	ASTM A36 carbon steel
Structural steel shapes	ASTM A36 carbon steel
Drive cage	ASTM A36 carbon steel
Main spur gear	
Ductile iron	ASTM A536, 100-70-03
Forged steel	AISI 4140, 4150 or 4340
Worm	Through hardened AISI 41L50 or 8620 alloy steel
Worm gear	ASTM B247, gear bronze alloy casting
Pinion	AISI 4140, 4142, 4150 or 4340
Main bearings	SAE 52100, Rockwell C64 or AISI E4140 43-46 RC
Spur Gear housing	Cast Iron ASTM A-48 Class 40A or Ductile Iron ASTM 536, Grade 65-45-12
Other gear cases	Cast or Ductile Iron
Turntable base	Cast or Ductile Iron
Submerged fastening hardware including anchor bolts	ANSI, Type 316 stainless steel
Truss arms and other misc. structural components	ASTM A36 carbon steel
Plow scraper blades, rear blade	ASTM A36 carbon steel
Seals	Neoprene
Bridge beams	ASTM A36 or ANSI, Stainless Steel (Type 304)
Walkway grating	Per Section 05 53 10 requirements
Guardrails and toeplates	Per Section 05 52 10 requirements
Guardrail Bolts, nuts and washers	Per Section 05 52 10 requirements

B. Materials specified herein are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

C. All carbon steel equipment shall be fully prepared with shop-applied NSF 61 certified typeE-5 coating with SSPC-SP5 surface preparation in accordance with the requirements of Section 09 90 00.

2.03 COMPONENTS

A. Drive Cage:

1. Torque shall be transmitted from the drive unit to the sludge collection arms by a drive cage. The drive cage shall encompass the center column and shall be of sufficient strength to transmit and/or carry all loads and stresses associated with 200 percent of the continuous operating torque. Drive cages shall be capable of accepting the specified design loads resulting from operation in both the clockwise and counter-clockwise directions. Calculations shall be provided showing the related stresses developed in the drive cage at the torque value specified.

B. Sludge Collector Mechanism:

1. Plow Scraper Blades:

a. General: Manufacturer shall be solely responsible for the design of the adjustable scraper blades (including quantity and dimensions). Sludge blades shown on the Drawings are for illustration purposes only and shall not be construed as design intent. Additional blades to transport sludge away from center column to withdrawal point shall be provided, if required by Manufacturer's design configuration.

b. Blades:

1) Thickness and stiffeners as required to limit blade deflections. Taper blades as required to match floor slope.

2. Sludge Collector Support:

a. The collectors shall be supported from the drive cage by steel truss arms to hold the collectors in alignment in a vertical and horizontal plane. The sludge collector arms shall be designed to withstand 200 percent of the continuous operating torque developed from uniform loads applied to all arms. In addition, each arm shall be designed to withstand a point load applied at its extreme end that produces cutout torque. Uniform loads and the point loading shall be applied separately. Calculations shall be provided showing the related stresses developed in the sludge collection arms under both conditions. Turnbuckles, guy cables, tie rods, and similar arrangements will not be allowed for support of the collector arms. The truss arms shall be of box or triangle truss construction, fabricated from rolled angles or sections having a minimum thickness of 1/4 inch. Maintain the width of the truss arm the same as the width of the center drive cage to ensure alignment and proper connection and rigidly connect the truss arm to the center drive cage. The truss arms shall conform to the slope of the clarifier floor and the truss arms shall support the segmented sludge scraper blades and all other affiliated components.

C. Drive Mechanism:

1. General:

a. The drive assembly shall include an electric gear motor with planetary or helical bevel gear reducer, pinion gear, turntable type main spur gear, drive base, shear pin hub coupling or sprocket, and mechanical torque overload protection system. The spur gear set shall be designed in accordance with AGMA 2001-B.

b. The drive mechanism shall be mounted on the center column with the top of the spur gear housing capable of supporting the total access bridge load by means of equally loaded, removable bridge supports. Drive mechanism components shall be designed for the rated torque specified herein. Calculations shall be provided that substantiate the torque rating (including momentary peak torque) of the gear assembly. Numerical values shall be shown for all terms used in the AGMA rating equations.

c. Drive mechanism shall be designed to inhibit reverse rotation.

2. Gear Reducer:

a. The gear reducer shall be of a Planetary/Helical or Helical Bevel modular design construction. It shall be capable of accepting high overloads and high ratios in a very compact package, while maintaining a high degree of efficiency. A cycloidal speed reducing unit, of drive manufacturer's standard offering and comparable features, performance and materials, may be provided. Cycloidal drive design shall not have less than 10 years' service in comparable applications.

b. If a planetary/helical gear reduction is provided, then the Planetary portion shall have two stages of reduction in a single piece housing made of Kymmenite ADI. The output stage shall have 4 planet wheels and the intermediate stage shall have 3 planet wheels made from case hardened steel (17CrNiMo6 or 16MnCr5). The output shaft and planet gears shall be mounted on a full complement of roller bearings. The tooth quality for the sun wheel and planet gears shall meet ISO 6 (AGMA 11) and the internal gearing must meet or exceed ISO 8 (AGMA 9) quality standard. The output planet carrier shall be a double flange design for high stiffness, large diameters of parts, and a short distance between input and output shaft. The intermediate planetary carrier shall have a single flange design for compact construction. The connection between the Sun Wheel and planetary carrier shall be gear teeth for optimized torque balance and full tooth contact. Dual Lip oil seals on the output shaft shall be standard.

c. The Helical gear reducer portion shall have gearing in compliance with ANSI/AGMA Standard 2001-B88, Bevel gearing in compliance with ANSI/AGMA Standard 2003-A86. Gears are to be carburized to a Hardness of 58–62 Rc for durability. The gearcase and flanges are to be made of high strength gray cast iron SAE Class 30. Double Lip oil seals on output shaft with additional inner seal made of Viton. Captured keys on input and output shafts. The efficiency of the gear unit is primarily determined by the gearing and bearing friction, and should range from approximately 95% for three stages of gear reduction to 98% for single stage reduction.

d. The Helical or Helical Bevel input housing shall be fabricated steel or cast iron and compact. While maintaining high efficiency, it must be modular in construction and totally adaptable to accept and Integral motor or NEMAC-Face Input. The reducer should be capable of running in horizonal or vertical positions.

e. The gear reducer must be capable of operating with mineral oil or synthetic oil and capable of operating under adverse environmental conditions.

f. The gear reducer shall be provided with an oil level sight glass.

3. Drive Motor:

a. The drive motor shall be 1,800 rpm conforming to Section 43 05 21. The motor shall be designed for continuous duty, Class II applications in accordance with AGMA 6019-E. The motor shall be Type 2 as specified in Section 43 05 21.

b. Motor bearings shall be rated for a minimum L-10 life of 100,000.

c. Power transmission between the gear motor and the pinion gear shall be via a direct shaft connection.

4. Pinion Gear:
   a. The pinion and pinion shaft which drive the internal spur gear shall be made from heat treated forged alloy steel and designed in accordance with AGMA 6010-E. The pinion shall be rigidly supported by bearings located above and below the pinion gear. Overhung pinions shall not be acceptable.
5. Spur Gear Assembly:
   a. The spur gear shall be AGMA Quality 5 and shall be designed and rated in accordance with 2001-B.
   b. The spur gear housing shall be made of cast iron. A felt or neoprene seal and dust shield shall be included with each spur gear housing in two locations; a lower seal located between the stationary drive base and main gear and an upper seal located between the main gear and stationary drive cover. The spur gear housing shall be designed to allow submergence of the gear face in the oil bath sufficient to provide complete lubrication of the gear assembly. When the main spur gear is manufactured from forged steel, a minimum of 75 percent of the gear face shall be submerged in oil. The gear case shall be complete with an oil fill and drain components. Drain piping shall tap the lowest point in the oil reservoir for removal of oil and condensate, shall be valved, and shall be conveniently accessible. An extension operator shall be provided for operation of the drain valve from the walkway level above. A dipstick extending from the walkway level to the bottom of the drain shall be provided to indicate oil level and the presence of condensate.
   c. The drive assembly shall be firmly mounted to a cast iron turntable base with a minimum wall thickness of 1/2-inch. The drive base shall be mounted on the center column and be provided with a positive leveling feature. The drive base shall be suitable for supporting the entire load the drive mechanism and access bridge. To permit inspection and maintenance of components in the interior of the drive unit housing, each assembly shall have an access opening of not less than 24 inches in diameter. Cover plate with lifting eyes securely attached shall be provided for the opening. The base shall be formed to provide a sump with a valved drain and sight glass not less than 1-5/16 inches deep to allow for the collection and disposal of condensate. The sump shall be designed to trap condensate before it comes in contact with bearing housings.
6. Main Bearing:
   a. The entire sludge collector mechanism shall be suspended from the turntable which in turn shall be supported on a ball bearing assembly that uses hardened carbon corrected, vacuum degassed alloy steel bearing balls, with nylon spacers. Bearings shall run in a hardened raceway (43-46 Rc), in a cross-contact or four-point angle contact bearing arrangement. The bearing balls shall run in an oil bath and be protected by dust and moisture seals. Minimum L-10 bearing life shall be 175,000 hours. The use of precision bearings is also acceptable.

7. Torque Overload Protection:
    a. The drive mechanism for the sludge collector shall be provided with a torque overload protection system. The overload protection system shall be designed to measure thrust of the worm or pinion gear shaft and be provided with an indicator showing the load on the mechanism. The indicator shall be visible from the access bridge, shall read in ft-lbs torque or percent continuous operating torque and shall cover the range of torques specified up to 200 percent of the continuous operating torque. The torque overload protection system shall be fully functional in the forward rotation of the mechanism.
    b. The overload protection system shall include two switches, the first to activate local and remote warnings, and the second to shut down the unit. The overload devices and switches shall be enclosed in a NEMA 4X watertight cast aluminum housing. The switches shall be DPDT, rated at 10 amps and 250 volts AC. The device shall be factory calibrated to activate the warning switch such that its contacts open when the torque load on the mechanism reaches 110 percent of the continuous operating torque and activate the cutout switch (normally closed) at 120 percent of the continuous operating torque.
    c. A backup shear pin shall be provided in a shear pin hub mounted on the output shaft of the gear motor. The shear pin shall be selected to break when the load on the mechanism achieves 140 percent of the continuous operating torque specified. A DPDT limit switch rated at 10 amps and 250 volts AC shall be provided to activate when the shear pin breaks. The shear pin device shall be capable of protecting the collector mechanism during forward collector rotation.
    d. Protective devices and switches must be suitable for installation in a Class I, Division 2 environment. Provide an intrinsically safe system in a NEMA 4X stainless steel enclosure to be mounted outside the hazardous envelope for interfacing with the switches for the overload protection system and shear pin device.

D. Walkway and Operating Platform:
    1. Access bridges shall be provided as shown for the sludge collector mechanism and shall consist of structural steel beam sections interlaced for rigidly. All walkway surfaces shall be at the same elevation. The access bridge shall be at the same elevation. The access bridge shall be supported on the main spur gear housing which in turn shall be supported by the center column support structure. The access bridge shall span the entire tank diameter. Calculations shall be provided showing the related stresses developed in the bridge for all load combinations.
    2. The bridge shall include a 36-inch wide aluminum grating walkway for the full span complete with 3/16-inch by 4-inch high toe plates. The operating platform shall include a similarly constructed walkway encircling the exposed portion of the drive unit. Clearance of 36 inches shall be provided around the drive.
    3. Removable sections of grating shall be provided to cover all wells or depressed areas in the walkway and access platform to provide a single plane for all walking surfaces.
    4. Walkway and operating platform grating shall be as specified in Section 05 53 10 and on the Drawings. The walkway and operating platform shall be provided with handrailing conforming to the requirements of Section 05 52 10.
    5. Provide supports from the access bridge for piping and electrical conduits.

E. Local Control Panel:
   1. Provide a NEMA 4X-rated, 316 stainless steel, local control station to be mounted at the center of the clarifier near the drive.
   2. The local control station shall be assembled and tested in accordance with the applicable specifications noted in Divisions 26 and 40.
   3. The panel shall have a HAND/OFF/AUTO selector switch whereby in HAND mode, the drive shall run without input from the PLC. In AUTO mode, the clarifier drive shall run with a discrete signal from the PLC. In OFF mode, the clarifier shall not run.
   4. A fault pilot shall be provided to signal a general fault with the clarifier.

F. Shop Finishing Requirements:
   1. Shop prime and finish drive mechanism.
   2. All steel or ferrous metal drive equipment, with the exception of stainless steel, shall be fully prepared with shop-applied prime and finish coats in accordance with the requirements of Section 09 90 00. Submit colors for Owner selection. One (1) gallon of touch up paint shall be provided for each mechanism.

2.04 SPARE PARTS

A. Procedures: Section 01 66 00.

B. Provide the following spare parts:
   1. Two complete sets of shear pins.
   2. One complete set of any special tools required to assemble, disassemble or maintain equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Equipment furnished under this section shall be installed, checked, and adjusted as recommended by the manufacturer. The installation shall be certified on Form 43 05 11-A as specified in Section 01 99 90.

B. Floor Clearance:
   1. The mechanism shall be used to screed the finish grout topping layer of the floor of the clarifier basin to a clearance tolerance of not less than 0.25-inch and not more than 0.50 inches between the collector squeegee and the finished floor surface.

3.02 FIELD TESTING AND START-UP

A. Procedures: Section 01 45 20

B. Perform the following tests:
   1. Performance Test:
      a. General:

1) All performance tests shall be performed under the on-site supervision of personnel trained by the manufacturer. All equipment and instrumentation necessary to complete the testing procedures outlined below shall be provided by the Contractor. Failure to complete the testing program, outlined in the following paragraphs, shall be sufficient cause for rejection. In addition, a factory representative shall start up the equipment and train plant personnel in operating and maintenance procedures.

b. Torque Test:

1) Load test the entire collector mechanism by anchoring collector arms individually. Each arm of the collector mechanism shall be tested individually by using a single attachment point at the end of the arm to achieve a point load condition during the test. In successive tests, demonstrate the sludge collection mechanism's (including drive unit, cage, gears and structures) capability to withstand all loads and stresses associated with the cutout torque. Prior to initiating the test, furnish the Engineer with sketches and calculations illustrating the test procedure and demonstrating how the specified torque will be applied to satisfy the requirement.

2. System Test:

a. Operating Tests:

1) The sedimentation basins shall be filled with water to their operating level and the clarifier mechanisms shall be operated continuously at their maximum speed for a period of not less than 48 hours. At no time during the operating test shall the equipment fail on torque overload or exhibit indications of binding or uneven operation. Record torque values as registered on the drive mechanism torque indicator and motor amperage (all three phases) at three-hour intervals.

2) If the mechanism should fail on torque overload or, in the opinion of the Engineer, the mechanism should exhibit indications of binding or improper adjustment, immediately halt the tests and remedy the problem. After completion of necessary repairs or adjustments, the tests shall be repeated. Failure to successfully complete the test in six attempts shall be considered sufficient cause for rejection.

3.03 MANUFACTURER'S SERVICES

A. On-Site Inspections and Training:

1. Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.

a. Operational Test Phase Testing Inspections:

1) Assist, supervise and inspect the Contractor's activities during the operational test phase specified in Section 01 42 20 and this Section. Provide 8 hours per visit (one visit per clarifier for a total of four visits) for inspection of operational test phase testing for the clarifier equipment. Complete Form 43 05 11-A, Section 01 99 90.

b. Training Session:

1) Procedures: Section 01 79 00

2) Provide a minimum of 8 hours of classroom training for one session. Certify completion of training on Form 43 05 11-B, Section 01 99 90.

END OF SECTION

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SECTION 46 43 76

INCLINED PLATE SETTLERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Inclined plate settlers and all appurtenant work, complete and operable, in accordance with Contract Documents for:
   1. Inclined Plate Settler Equipment in two (2) new sedimentation basins.

B. Requirements include furnishing individual inclined plate pack assemblies for installation in concrete basins as shown on the drawings and specified herein. Supplier shall also provide layout for future plate installation, if shown on drawings, including support spacing.

C. Plate pack assemblies shall include the following Manufacturer supplied items: plates; frames; troughs; flow control baffles; embedment pieces; anchor assemblies; and bolts for attachment to concrete supports.

1.02 RELATED SECTIONS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 11 80: Environmental Conditions
   2. Section 01 33 00: Submittal Procedures
   3. Section 01 73 24: Non-structural Components and Non-building Structures
   4. Section 01 78 23: Operation and Maintenance Data
   5. Section 01 79 00: Demonstration and Testing
   6. Section 05 05 20: Anchor Bolts
   7. Section 05 50 00: Metal Fabrications
   8. Section 43 05 11: General Requirements for Equipment

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AISC 341	Specification for Structural Steel Buildings
AISC 360	Seismic Provisions for Structural Steel Buildings
AISC 370	Specification for Structural Stainless Steel Buildings

Reference	Title
ANSI/NSF 61	Drinking Water System Components
ASTM A36	Standard Specification for Carbon Steel
ASTM A167	Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet and Strip
ASTM A267	Stainless and Heat Resisting Steel Bars and Shapes
ASTM A320	Alloy Steel Bolting Materials for Low Temperature Service
ASTM A480	General Requirements for Flat-Rolled Stainless and Heat Resisting Steel Plate, Sheet and, Strip
AWS D1.1	Structural Welding Code – Steel
AWS D1.6	Structural Welding Code – Stainless Steel
IBC	International Building Code (with Local Amendments)

1.04 SYSTEM DESCRIPTION

A. One Inclined Plate Settler Manufacturer shall supply all equipment specified in this Section.

B. Plate settler equipment, including place modules (or packs), frames, effluent troughs, and support system shall be installed in two new sedimentation basins at the City Creek Water Treatment Plant located in Salt Lake City, Utah.
   1. Each plate settler system shall be installed in a sedimentation basin for the purpose of removing solids from water.

C. Basis of Design
   1. The structural and mechanical design for the inclined plate settlers are based on information provided by the listed Inclined Plate Settler Manufacturers. Layouts and drawings show orientations for the first listed manufacturer. Fundamental changes in the configuration of the plate settler system will not be allowed. The Supplier shall submit drawings and supporting documents, identifying all proposed changes, to the Engineer for approval. Supporting documents shall delineate all proposed changes including complete structural calculations stamped and signed by a Structural Engineer registered in the state of Utah.
   2. Process Design:
      a. Plate packs shall be protected by a curb or apron to prevent the water surface from submerging the plates at maximum hydraulic flow rate.
      b. Troughs shall be designed to allow a maximum of 5 inches of headloss as flow passes from plate settlers into effluent troughs over a weir at the design flow rate.
      c. The maximum feed velocity into the plate pack shall be 0.5 ft/sec to prevent floc destruction and hydraulic disturbances.
      d. Feed through the bottom end of the plate shall be minimized to prevent solids re-entrainment.
      e. Effluent troughs are to be located on each side of plate packs to prevent maldistribution. After exiting the plates, water shall travel no more than ½ of a plate width to reach an effluent trough. Effluent troughs shall be of the dual side-loaded design and be located on both sides of the plate settler frame assembly.

3. Structural Design:
    a. The structural design of the plate settler system shall be in accordance with the requirements of the International Building Code (IBC).
    b. Plate settlers, frame, supports, troughs, and anchorage system shall be designed per the environmental conditions specified in Section 01 11 80.
    c. Inclined Plate Settler support frames shall be designed for the worst-case load condition of an empty basin and full effluent troughs. The effluent troughs shall be designed such that maintenance personnel can walk on the troughs when the troughs are empty.
    d. Plate settler shall be designed to allow maintenance personnel to walk on top of the plate packs.
    e. Plate settlers, frame, supports, troughs, and anchorage system shall be designed per seismic criteria, specified in Section 01 73 24 including effects of water slosh during a seismic event.

D. Inclined Plate Settlers:

1.	Total Sedimentation Basin Design Capacity (Basin 3 through 6):	17.6 mgd
2.	Number of Basins	2
3.	Maximum Design Flow Rate per Basin:	8.8 mgd
4.	Minimum Design Flow Rate per Basin:	2 mgd
5.	Maximum Hydraulic Flow Rate per Basin:	10 mgd
	a. plate settlers must pass this flow without submerging the weirs or troughs; this is not the design process flow	
6.	Maximum Design Effective Hydraulic Loading Rate:	0.30 gpm/ft^2
7.	Total Effective Projected Settling Area Percentage (efficiency):	80%
8.	Minimum Effective Projected Settling Area per Basin:	20,370 sq ft
9.	Water Temperature Range:	33 to 80 °F
10.	pH Range (standard units):	6.0 to 9.0
11.	Angle of inclination between the plates and the horizontal:	55 degrees
12.	Maximum Dose of Primary Coagulant	TBD
	a. System shall be compatible with all ferric- and aluminum-based coagulants	

E. Basin Geometry:
    1. Each sedimentation basin is approximately 40-feet wide and 61-feet long with a side water depth of TBD ft.

F. Weirs
    1. Straight Weirs
        a. Each trough shall be equipped with adjustable bolt-on flat-crested or straight weirs for leveling during initial installation and to provide an even flow distribution during operation.
        b. The weir shall be designed so each plate pack has a continuous weir for even flow distribution.
        c. The flat crested weirs shall be securely fastened by continuous pressure clamp.
        d. Flat crested weirs shall be designed to set top deck flow depth to less than 2 inches.

e. Adjustable weirs shall be gasketed with 1/8" thick EPDM or appropriately sealed with an NSF-61 compliant sealant.

2. V-notch Weirs
   a. Each trough shall be equipped with adjustable bolt on v-notch weirs for leveling during initial installation and to provide an even flow distribution during operation.
   b. The v-notch weir shall be designed so each plate has two individual v-notches for even flow distribution.
   c. The v-notch weirs shall be securely bolted to the effluent troughs with 3/8" Type 316 SS through bolt connection a minimum of every 12 inches.
   d. V-notch weirs shall operate at a minimum water elevation of 4 inches above the top flow control angle at design flow.
   e. Adjustable weirs shall be gasketed with 1/8" thick EPDM or appropriately sealed with an NSF-61 compliant sealant.
   f. V-notch weir design shall be such that top edge of plate is continuous rather than "serrated" for the purpose of protecting wash water hoses from damage when routed over weir and trough. Design shall not expose operator to sharp edges or corners.

G. Responsibilities:
   1. Plate Settler Manufacturer is responsible for delivery of equipment and supplies required under these specifications.
      a. Plate settlers shall be constructed of materials, certified or classified by NSF or underwriters laboratories as meeting ANSI/NSF Standard 61.
      b. Proper coordination and integration of all equipment required for supply in the basins, including plate pack assemblies, support beams and columns, and all other associated work shown on the drawings and specified in the Contract Documents.
      c. Ensuring that the plate settler system shall be properly coordinated and will function as a unit in accordance with these specifications.
      d. Ultimate responsibility for equipment coordination, installation, operation, and guarantees.
   2. The Contractor will be responsible for:
      a. Proper coordination with Suppler and installation of all equipment in the basins including plate pack assemblies, support beams and columns, piping, and all other associated work shown on the drawings and specified in the Contract Documents.
      b. Ultimate responsibility for equipment installation.

1.05 PERFORMANCE REQUIREMENTS

A. The inclined plate settlers shall operate to meet the following performance conditions. In the event of noncompliance, the Inclined Plate Settler Manufacturer shall make all necessary adjustments, repairs and/or modifications necessary to meet the requirements before the Work will be accepted.
   1. Maximum Design Flow Rate per Sedimentation Basin = 8.8 mgd
   2. Minimum Design Flow Rate per Sedimentation Basin = 2 mgd

3. Minimum Freeboard within Effluent Trough = 5 inches @ Maximum Hydraulic Flow Rate
4. Maximum Headloss Induced by the Plate Settlers = 1.5 inches @ 8.8 mgd (Measured from the weir elevation to the basin water surface upstream of and outside of the first plate pack).
5. Maximum Flow Maldistribution along a Plate Pack Row = less than 10% (Measured between the first and last plate pack in a given row of plate packs at 8.8 mgd per basin).
6. Maximum acceptable daily average turbidity in the plate settler effluent trough shall be no greater than 1.0 NTU 95% of the time with influent turbidity at 1-30 NTU at 8.8 mgd as measured over a 2-week test period.

1.06 SUBMITTALS

A. All submittals shall be as specified in Section 01 33 00. Note that the Supplier will need an approved submittal early in the project to meet interim project milestones.

B. Product Data and Calculations
   1. Design calculations to substantiate the proposed plate settler design. Calculations shall include at least the following:
      a. Plate area calculations.
      b. Detailed hydraulic calculations, including a hydraulic profile, at maximum design sedimentation basin and plant flow rates, across the inclined plate settlers showing the water surface elevations in the sedimentation basins upstream of the plate packs, through the effluent troughs, and into the settled water channel at the point of connection with the effluent troughs. Hydraulic calculations shall also include effective hydraulic loading rates of the units and flow velocities between plates and between rows of plate packs; flow velocities throughout the unit (feed box velocities, plate influent velocities, and plate velocities).
      c. Headloss through unit.
      d. Water surface elevations upstream of the effluent weir, in the effluent trough and in the sedimentation basin. Show these elevations on the submittal drawings.
      e. Effective hydraulic loading rates of unit.
      f. Maldistribution testing results.
      g. Weight of the equipment and its distribution on the supports for worst- case design conditions.
   2. Structural Calculations
      a. The Supplier shall submit complete structural calculations stamped and signed by a Structural Engineer registered in the state of Utah, in accordance with Section 01 33 00. The calculations shall demonstrate full compliance with the structural requirements specified for this Project on the Drawings and in Section 01 73 24.

C. Shop Drawings: Submit drawings and descriptive data of inclined plate settlers for review. Sufficient information is to be provided to show equipment conforms to specification requirements and allows for proper installation of equipment by Contractor. This includes, but is not limited to the following:
   1. Complete dimensional, and installation drawings and details.
      a. Elevations of weirs, flumes, troughs, and other controls;
      b. Materials and details of construction;
      c. Pertinent manufacturer's data and details of special features;
      d. Load distributions for the plate packs onto the supports (for the worst case design condition)
      e. Certified dimensional drawings for plate settlers and support system. Include support anchor bolt and anchorage details.
      f. Fabrication drawings, including weld types
   2. Diagram of the system that details which part of the equipment is completely submerged during normal operation and at the air/water interface.
   3. Flow diagrams of system showing location of equipment and devices;
   4. Parts list and other materials,
   5. Recommended shipping and storage procedures.
   6. Installation details and procedures identifying acceptable methods of lifting, lateral movement, leveling, and anchoring.
   7. Material data sheets.
   8. Conformance with ANSI/NSF 61 classification.
   9. Cross sections and details, as required, to satisfy Engineer and Contractor for the detailed design and location of all connecting or adjacent structural and mechanical items such as foundation, anchor bolts, steel and concrete supports, piping, conduit, etc.
   10. Any recommended or required deviations from the dimensions and locations of connecting or adjacent items as shown in the Drawings shall be described completely in the submittal.
   11. Operation and maintenance data per Section 01 33 00 required prior to submittal of Owners manuals.

D. Experience and References:
   1. Provide documentation indicating manufacturers qualifications as outlined in Section 1.06 of this specification.
   2. Provide contact name and phone number for reference on previous projects.

E. Welder certifications from a recognized testing laboratory demonstrating that the plate pack welders are qualified and experienced in welding stainless steel; and will demonstrate testing of welders using different types of welds, welding positions, etc.

F. Installation Manuals: The Inclined Plate Settler Manufacturer shall provide electronic copies of written Installation Manuals. The installation manuals shall provide complete and clear field erection instructions as well as recommended storage procedures prior to installation. The installation manuals shall be submitted at least two (2) weeks prior to shipping the first set of plate packs to the Project Site.
   1. Installation procedures identifying acceptable methods of lifting, lateral movement, leveling, and anchoring. Also include procedures for connecting the plate pack units to one another and to the settled water channel.

G. Owner's Manuals: The Supplier shall submit Owners Manuals in accordance with Section 01 78 23. The manuals shall address the following areas:
   1. Brief description of inclined settling plate components;
   2. Routine maintenance and cleaning procedures;
   3. Operation and maintenance instructions, parts list, illustrations and diagrams.

1.07 QUALITY ASSURANCE

A. Manufacturers Qualifications:
   1. Experienced in the production and manufacture of substantially similar equipment during the 5 years prior to the issuance of this contact, and able to submit evidence of satisfactory operation in at least 5 different installations.
   2. Plate settler manufacturer to provide support system troughs, plate settler modules, and all other components required providing a complete and operational plate settler system. All components shall be provided by a single manufacturer. The support system shall include all frames, columns, and beams required for a complete installation.
   3. The manufacturer shall be solely and fully responsible for the warranty and mechanical design adequacy of all the provided components under this section.

B. Shop Inspection:
   1. Shop inspection may be required by the Owner at its own expense. The Supplier shall give at least three (3) weeks notice to the Construction Manager prior to beginning of any fabrication work so that inspection may be provided. The Supplier shall furnish all facilities for the inspection of materials and workmanship in the shop and inspectors shall be allowed free access to the necessary parts of the works. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of these Specifications. Inspection at the shop is intended as a means of ensuring high quality workmanship and of facilitating the work, but it is expressly understood that it will in no way relieve the Supplier from responsibility for furnishing proper materials or workmanship under this Specification.
   2. Plate pack units shall be completely assembled in the shop to assure accurate plate spacing.

C. Workmanship

1. Workmanship in the fabrication of the inclined plate settlers shall be first-class, including the following requirements. The assembled plate packs shall have members that are straight and true. Structural distortions, warps, and other defects shall not be present in the plate pack assemblies before or after installation in the sedimentation basins. All exterior surfaces and edges of the plate packs shall be smooth. Sharp corners shall be ground round and smooth.
2. All welding shall be done in accordance with the latest applicable code and other pertinent standards of the American Welding Society (AWS). Qualification of welders shall be in accordance with AWS standards. Welding of stainless steel shall be performed by welders experienced in stainless steel welding. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS Code. Upon completion of welding, all weld spatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workman- like appearance, with uniform weld contours and dimensions. Finished welds shall be neat in appearance.

1.08 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Pack as required for shipping and outdoor storage at the project site for up to 6 months. Provide lifting lugs or other means for unloading and/or installation. Include special handling instructions and provide picking spreader as needed. Plate settlers shall be shipped with cardboard end caps and corner pads to protect plates from damage during shipping and storage.

B. Storage and Protection: The Contractor will prepare the staging area for storing plate packs. The area shall be as designated on the Drawings. The storage area shall be graded with aggregate rock to form a firm, well-draining storage area. Plate packs shall be covered and kept clean at all times.

C. Protect finished surfaces which may be damaged during installation with removable tape or suitable alternate.

1.09 SPARE PARTS

A. Special tools as required for assembly or disassembly of the plate settlers and support system.

B. Spare parts as recommended by the manufacturer packed in containers which are clearly identified as to their contents. Pack all items for long periods of storage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Provide equipment as manufactured by the following:

1. Meurer Research, Inc. (MRI).
2. Jim Myer and Sons (JMS).

2.02 GENERAL

A. All equipment shall be designed for continuous, 24-hour operation. All parts of the product shall be amply proportioned for all stresses, which may occur during fabrication, installation, and operation.

B. Stainless steel nameplates giving the name of the manufacturer, model number, the rated capacity, shipping and operating weights, and any other pertinent data shall be attached to each unit.

C. The plate settler manufacturer shall coordinate the design and installation of the plate packs and support system with the hydraulic solids scraper manufacturer.

D. Fabrication:
   1. All welding shall be performed by qualified personnel in strict accordance with manufacturer recommendations and in accordance with the latest requirements of AWS.
      a. Sharp corners of all cut or sheared edges shall be ground smooth where practical.
      b. Welds shall be rough ground to remove heavy weld ripple or unusual roughness per the latest recommended practices of AWS.
      c. Acceptable welding methods shall include MIG, TIG, stick-electrode, or as per the manufacturer's recommendations.
   2. All welds shall be fully cleaned and passivated after completion of welding operations. All pastes and solutions shall be disposed of in accordance with all applicable laws and regulations.

E. The components of the Inclined Plate Settlers shall be made from the following material:
   1. Plates: Type 304 SST (Type 304L SST if welded)
   2. Frames: Type 304L SST
   3. Columns: Type 304 SST (Type 304L SST if welded)
   4. Beams: Type 304 SST (Type 304L SST if welded)
   5. Trough/Flume Assembly: Type 316 SST (Type 316L SST if welded)
   6. Ladder Assembly: Type 316L SST
   7. Slide Gate: Type 316 SST (Type 316L SST if welded)
   8. Baffles Type: 316 SST (Type 316L SST if welded)
   9. Adjustable Weirs: Type 316 SST (Type 316L SST if welded)
   10. Gaskets: EPDM Rubber
   11. Nuts, bolts, fasteners: 316 SST (in accordance with Section 05 50 20)

F. All components of the Inclined Plate Settlers that are not completely submersed under normal operation or at the air-water interface shall be constructed out of Type 316 stainless steel (Type 316L SST if welded).

2.03 PLATE PACKS

A. Plate settler modules consisting of metal sheets stacked and assembled in a pack or module.

B. The channels shall have a sufficient cross-sectional area, and shall be oriented on an angle of 55° from the horizontal, to promote gravity drainage of solids collected on the plate bottoms.

C. Minimum perpendicular plate spacing shall be 2 inches, nominal.

D. Plate settler modules shall fit in the corresponding sedimentation basin as indicated on the Drawings.

E. The plates shall be proven to support a 30 lb. solids loading.
   1. The plate shall be designed to handle a 30 lb. solids loading evenly distributed over the plate without failing, buckling, yielding, or creating a permanent deformation. The plate shall not exceed a maximum deflection of L/140 anywhere along the plate width and shall have center stiffeners as needed to prevent deflection of plates.
   2. The manufacturer shall provide a stamped report from a third-party testing laboratory in compliance with ASTM E330 and proving that the L/140 testing criteria is met.

F. Connectors
   1. Flexible connections shall be provided between each plate pack. Connectors shall be Neoprene sleeves with Type 304 stainless steel clamps.
   2. All gaskets and sleeves shall be neoprene.

2.04 EFFLUENT ASSEMBLY

A. The effluent assembly shall consist of side-mounted effluent troughs for each row of plate packs, and protected by perimeter aprons or separation walls that prevents flow in the basin from bypassing the plate packs. Both shall be constructed with a minimum thickness of 14 gauge.
   1. Troughs shall be of the dual side load arrangement, meaning one effluent trough per frame assembly shall not be allowed.
   2. The effluent trough shall be sized by Supplier. Flow into the trough will be controlled by continuous weirs.

B. The effluent trough shall be of continuous construction, or have a sealed connection, by use of SST and NSF 61 approved gaskets, between adjacent plate packs.

C. Minimum Number of Troughs and Minimum Trough Depth per Basin:
   1. Minimum Number of Troughs: TBD
   2. Minimum Trough Depth of Inclined Settler Plate:
      a. Exterior to Plates: 8 inches

D. The effluent trough/ flume assembly shall be reinforced as necessary to handle the loads transmitted from the effluent trough to the effluent flume, and the loads due to maintenance activities. Lateral stiffness and rigidity shall be provided if necessary through the use of spreaders placed at strategic points along the length of the flume and fastened with Type 316 stainless steel hardware. The stiffeners shall be above the design operating water level in the flumes. To satisfy horizontal and vertical deflection requirements, angle stiffeners shall be used to reinforce the sides of the trough.

E. Each trough shall be equipped with adjustable weirs for leveling during initial installation and to provide an even flow distribution during operation. Troughs located above the plate settlers obstructing access to the tops of the plates shall not be accepted.

2.05 TOP FLOW CONTROL DEVICE

A. Each plate shall be equipped with an integral Type 304 stainless steel top flow control device (angle or perforated tube) to ensure that there is an even flow distribution across the entire surface area of the plate.

B. Top flow control device shall provide a suitable walking surface for routine cleaning and maintenance without the use of a temporary walking surface, such as plywood. No part of the plate settler system shall deform or fail due to walking on top of the plates.

1. The manufacturer shall provide a P.E. stamped report from a third-party in compliance with ASCE 7-10 (Minimum Design Loads for Buildings and Other Structures) referencing catwalks for maintenance access. Specifically the flow control deck shall be designed using a minimum uniformly distributed live load of 40 psf and a minimum concentrated live load of 300 pounds. The top flow control device shall not experience any buckling, permanent deformation, or yielding.

2.06 ACCESSORIES

A. All brackets, fasteners, anchor bolts and similar items necessary to secure and support the furnished equipment on concrete beams within the basin shall be furnished by the equipment manufacturer and installed by the Contractor in accordance with the manufacturer's instructions.

B. Plate settler manufacturer shall equip the center most effluent trough per basin with a 1-inch stainless steel threaded nipple located below the water surface elevation within the effluent trough for sampling purposes as indicated by the Drawings. The location of the nipple shall be at the end of the trough and shall be coordinated with the Contractor.

2.07 SURFACE FINISH/CLEANING

A. All Stainless Steel components shall be protected, cleaned and tested as follows:

1. Stainless steel components shall be protected from carbon steel contamination during fabrication and assembly as defined in Paragraph 8 of ASTM A380. Surfaces surrounding joints shall be cleaned as discussed in Paragraph 6.3 prior to welding. Careful adherence to good stainless-steel practices may minimize descaling and cleaning requirements.
2. Welding temperatures shall be carefully monitored as to not sensitize the material and thereby increase the risk of intergranular corrosion.
3. After completion of welding, all surfaces shall be descaled as necessary using methods described in Paragraph 5 of ASTM A380. Welded surfaces (including surfaces within the heat affected zone of the weld) shall be descaled using a pickling solution as discussed in Paragraph 5.2. Surfaces shall be thoroughly rinsed in accordance with Paragraph 5.2.5.
4. Following descaling, all surfaces shall be cleaned as necessary using methods described in Paragraph 6 of ASTM A380. Final cleaning of all surfaces shall be in accordance with Paragraph 6.4 of ASTM A380.

5. Upon completion of cleaning, all surfaces shall be visually inspected in accordance with Paragraph 7.2.1 prior to testing. Any gross indications of Iron as defined in Paragraph 7.2.1.1 shall be cleaned as necessary.
6. Testing to ensure proper passivation and cleaning has occurred shall be as defined in Paragraph 7.2.5 of ASTM A380. First, perform a water-wetting and drying test on all stainless-steel surfaces in accordance with Paragraph 7.2.5.1 of ASTM A380 or a Practice A – Water Immersion Test as defined in Paragraph 14.1 of ASTM A967. Failed areas shall be re-cleaned and retested using a Copper Sulfate Test in accordance with Paragraph 7.2.5.3 of ASTM A380 or Practice D – Copper Sulfate Test found in Paragraph 14.4 of ASTM A967 . Any remaining failed areas shall be cleaned using a nitric acid solution in accordance with Table A2.1 Part II of ASTM A380 followed by retesting of all affected areas using a Copper Sulfate Test.
7. Manufacturer shall notify Engineer of any failed tests. No equipment shall be shipped without certification that all surfaces have passed inspection and testing. Manufacturer shall remove test chemical in accordance with the testing manufacturers recommendations. No visible indications of Iron may exist prior to shipment. Any evidence of rust or blooming upon arrival on site shall be the responsibility of the manufacturer to address.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect all components, upon delivery, for shipping damage and conformance to specifications prior to installation. Repair or replace damaged items as directed by Construction Manager, including visible corrosion, at no additional cost to the Owner. Only factory-trained manufacturer's representative shall perform repair work.

3.02 INSTALLATION

A. Plate settler modules shall be provided in such configurations to minimize, if not eliminate, field modification.

B. Contractor will install Supplier’s products in accordance with manufacturer’s instructions.
   1. In general, installation shall include:
      a. Install bolts, nuts, and washers at all mounting locations for each plate pack.
      b. Install shims under anchor plates where necessary to meet the installation tolerances.
      c. Install flume connections to the collector trough and between plate packs.
      d. Install gaskets, bolts, nuts, and washers.
      e. Adjust weir plate to required elevation.
      f. Apply sealant around all gaskets after plate pack connections have been made and around all weir plates after elevations have been verified.
      g. Level plate pack supports with non-shrink, nonmetallic grout.

h. Install and level the plate pack units and troughs in accordance with the Manufacturer's recommendations and the Drawings. All plate settler support anchor locations shall be leveled to within +/- 1/8 of an inch. Contractor shall exercise care in erecting and leveling the plate settlers, troughs, and weir plates so that the units are at the elevations shown on the Drawings or specified herein and have deflections within the manufacturer's specified limits.

C. After installation, all weirs shall be leveled to within 1/16 of an inch of target elevation as shown on the Manufacturer's drawings. All brackets, fasteners, and similar items necessary to secure the furnished equipment in the basin shall be furnished by the Manufacturer.

3.03 FIELD TESTING

A. Contractor will perform all testing under the supervision of the Manufacturer's representative. The Contractor will conduct all specified tests and furnish all labor, equipment, materials, and supplies to conduct these tests. The Contractor will be responsible for sample collection, shipping, and analyses of all test samples. The Contractor will provide the Construction Manager with sufficient advance notice of the testing to enable the Supplier and Construction Manager to witness the tests.

B. Supplier shall provide the Contractor with protocols for all tests describing the type of test, test procedures, instrumentation used, proposed flow rates, and other information necessary to describe the proposed testing plan.

C. The effluent quality of the settled water must meet the performance requirements specified herein.

D. The inclined plate settlers shall demonstrate compliance with the specified hydraulic requirements. The inclined plate settlers shall be demonstrated to have the hydraulic capacity specified without maldistribution of flow or requiring more than the specified maximum headloss.

E. If a basin or individual plate pack assembly fails to meet specified performance requirements, the Supplier shall direct the Contractor to make necessary corrections and retest the settling basin or plate pack until the performance test is satisfactorily completed. No additional payments will be made for retesting.

F. Functional Testing
   1. Complete Functional Testing in accordance with Section 01 79 00.

G. Installation Tolerance:
   1. For the weirs on the plate pack trough, the maximum allowable variation shall be ±1/8-inch to achieve the water surface elevation indicated on the Drawings at maximum flow.

H. Tolerance shall be verified prior to filling with water. The Contractor will provide equipment to verify tolerances. Operational Testing: As specified in Section 01 79 00.
   1. Upon completion of testing, the Supplier shall submit to the Construction Manager a copy of the completed test reports. Reports shall include description of the units tested, test procedures, test flow rates, pressures, levels, and all other data and results required to demonstrate that the equipment meets specified requirements.

3.04 MANUFACTURER'S FIELD SERVICES

A. The CONTRACTOR shall coordinate field service work with the Manufacturer's representative, Owner, and Construction Manager prior to initiating such work.

B. The manufacturer shall provide a qualified field technician to perform the following:
   1. Inspect the system before initial start-up and verify that system has been correctly installed, as specified herein and in Section 01 79 00, prior to filling with water.

C. The Manufacturer shall provide the services of a factory field service technician or Engineer as follows:
   1. To include, but not limited to, four (4) trips to the site, totaling 20 days of on- site work. A day on-site shall be considered to be 8 hours in duration.
   2. Observe/advise the Contractor on the installation of the settler equipment.
   3. Check and verify that installation of the plate pack assemblies is in accordance with the Drawings and Manufacturer's installation instructions.
   4. Should chemical addition be required to meet performance requirements, settler Manufacturer shall recommend adjustments in coagulant chemical dosages.
   5. Assist in start-up and testing of the settler system as required.
   6. Instruct the Owner's personnel on operation and maintenance of the settlers. Personnel instruction shall consist of not less than one (1) day of classroom and field training. Subjects shall include the following:
      a. Troubleshooting.
      b. Operating adjustments for performance optimization.
      c. Preventive maintenance.
      d. Maintenance procedures.

END OF SECTION

SECTION 46 43 80

HOSELESS SOLIDS COLLECTION SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:

1. This Section specifies the solids collection system equipment for use in separation of solids in the flocculation/sedimentation process as shown on the Drawings.
2. Provide and install solids collector systems which include tandem collector assemblies, electric drive assemblies and controllers, drive cables, sensors, rigid solids conduit, cable pulleys, control system for a fully automatic or manual operation, and all other miscellaneous accessories and hardware as required for a complete and functional installation.
3. The solids collector equipment shall be provided as an integral package by a single manufacturer regularly engaged in the production of this equipment. The solids collector system shall be assembled in full conformity with drawings, specifications, and instructions furnished by the equipment manufacturer.
4. The solids collectors shall remove the settled solids from the basin floor. Flow shall be gravity driven. The solids shall be discharged through rigid solids conduits which are connected to the fixed piping to exit the basin.
5. The solids collectors shall be designed to fit the configuration of existing sedimentation basins without the need for structural modifications other than those included in the Contract Drawings.

B. EQUIPMENT LIST:

Item	Equipment Number
Solids Collector 1 A	40-COL-10010
Solids Collector 1 B	40-COL-10020
Solids Collector 2 A	40-COL-20010
Solids Collector 2 B	40-COL-20020
Solids Collector Drive 1 A	-
Solids Collector Drive 1 B	-
Solids Collector Drive 2 A	-
Solids Collector Drive 2 B	-

C. OPERATING REQUIREMENTS:

Component	Value
Number of Basins, quantity	2
Dimensions of each basin, ft x ft	61 x 40
Number of Units per Basin	2
Design Flow Rate per unit, gpm	100-150
Design cycles per day per basin	TBD
Collector Speed, ft/min	TBD
Maximum headloss through orifices, ft	TBD
Sidewater depth, feet	14.6
Maximum Motor, horsepower	1/4, (Conform to Section 43 05 21)
Motor Voltage/Phase	480V/3 Phase

1.02 QUALITY ASSURANCE

A. REFERENCES:

1. This Section contains references to the following documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

Reference	Title
ABMA-9	Load Ratings and Fatigue Life for Ball Bearings
AGMA 2001-B	Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
AGMA 6013-A	Standard for Industrial Enclosed Gear Drives
AISC	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design
AISI	Pocketbook of ASI Standard Steels
ASTM A36	Structural Steel
ASTM A48	Gray Iron Castings
ASTM A536	Ductile Iron Castings
ASTM A666	Austenitic stainless steel, sheet, strip, plate and flat bar for structural application
ASTM B247	Aluminum-Alloy Die Forgings, Hand Forgings and Rolled Ring Forgings
ASTM E18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
AWS D1.1	Structural Welding Code—Steel
NEMA 250	Enclosures for Electrical Equipment

B. UNIT RESPONSIBILITY:

1. The Contractor shall assign unit responsibility to the manufacturer of the Solids Collection Equipment provided under this section. This manufacturer is the unit responsibility manufacturer and has unit responsibility, for both the equipment assembly specified in this section, motors specified in Section 43 05 21, and VFD and all other equipment assembly components specified elsewhere but referenced in this section. A completed, signed, and notarized Certificate of Unit Responsibility (Form 43 05 11-C, Section 01 99 90) shall be provided.

C. FACTORY TESTS:

1. Perform factory tests of all equipment and controls associated appurtenances of the solids collection equipment prior to delivery onsite.

D. MANUFACTURER'S EXPERIENCE

1. Manufacturer shall have at least 10 installations of the proposed design. Solids collectors sold under other names, corporate identities or ownership; or not directly fabricated and supplied by the manufacturer will not be considered as meeting the experience qualifications.

E. SHIPMENT, PROTECTION AND STORAGE:

1. The equipment shall be protected during shipment and storage as specified in Section 01 66 00.

1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Certificate of Unit Responsibility (Form 43 05 11-C) attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section specified in 1.02B. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

3. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this Section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required".
4. Documentation of experience specified in 1.02D. Provide a list of 10 hoseless solids collector installations of the design complying with these specifications and proposed for this project. All applications shall be municipal applications. Provide names and phone numbers of at least five references in operation for at least five years.
5. General arrangement drawings showing the entire assembly. This shall include a materials list and descriptions of all major components such as all gears, structural members, solids collection members, and the scum removal system (sizes, piping connections, ASTM designations where appropriate, thicknesses, and construction).
6. Rating, AGMA and ASTM designations, construction, and detailed descriptions of all gears, reducers, and drives.
7. Complete shop drawings of all equipment furnished.
8. Design and layout of equipment indicating all dimensions.
9. Head loss calculations through the solids collector.
10. Bearing manufacturer, bearing model, and ABMA L-10 life data.
11. Shop and field painting systems. Include the manufacturer's descriptive technical catalog and specifications. Submit drive finish coat colors for Owner selection.
12. Manufacturer's data including product literature, materials of construction, construction details of equipment, wiring diagrams, and weight of equipment.
13. Connection locations and attachment details.
14. Motor submittal data as specified in Section 43 05 21.
15. Control panel interconnection diagrams including field connections and connections to the plant control system. Boiler plate diagrams are not acceptable.
16. Drawings of the control panel including elevation of both exterior and interior including dimension.
17. Seismic design calculations per the requirements of Section 01 73 24

1.04 ENVIRONMENTAL CONDITIONS

A. Environmental conditions will be as described in Section 01 11 80.

1.05 SEISMIC ANCHORAGE AND STRUCTURAL DATA

A. Mechanical, instrumentation and control, electrical, nonstructural systems, components, and elements permanently attached to the structure shall be anchored and braced to resist seismic forces. Contractor shall design the structural components, seismic attachment, braces, and anchors to the structure for all parts or elements of the mechanical and electrical systems in accordance with Section 01 73 24.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the following candidate manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's product, nor shall it be construed that a named manufacturer's standard product will comply with the requirements of this Section. Candidate manufacturers include Meurer Research Inc., JMS, or approved equal. The Owner and Construction Manager are not aware of an equal manufacturer.

2.02 MATERIALS

Component	Material
Header Assembly and Pipe	304, 316 Stainless Steel
Casters	Polyurethane, Solid Urethane
Drive Cable	304 Stainless Steel

A. All fabricated stainless steel components shall be passivated to prevent future corrosion. All welds shall be passivated by mechanical cleaning per ASTM A-380 and cleaning with an NSF approved acid solution. Nitric acid or other hazardous chemicals shall not be allowed for cleaning. Non-welded parts shall be supplied with standard mill finish.

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 FEATURES

A. General:
   1. Motor bearing are factory lubricated and sealed for life.
   2. Motors shall be inverter duty rated and comply with the requirements of Section 43 05 21.

B. Reel Drive Assembly
   1. Each drive assembly shall consist of a motor, which shall be coupled to a single rotating drum for manipulation of the cable that is attached to the tandem collector assembly.
   2. The cable shall be firmly attached to the rotating drum to prevent slippage. Tensioning the cable between multiple pulleys to prevent slippage will not be allowed.
   3. The cable shall store on the reel in a single layer, the placement of which shall be organized by the drive mechanism.
   4. The complete drive mechanism shall be packaged on a single base and provided with a powder coated aluminum or stainless steel safety enclosure.
   5. The drive cable shall be of a minimum diameter of 1/4". Pneumatic or steel tape drive systems are not acceptable.

6. The drive assembly shall be capable of ceasing operation on an excessive load without physical damage to the drive unit. During an overload, protection built into the VFD will cease operation and activate an alarm locally at the control panel. Operation will continue after alarm is reset. Back up protection in the form of a shear pin is required.
7. The drive assembly shall have integral position sensors which determine when the collector is at the end of the basin, the beginning of the basin and points in-between. No external or under-water position sensors shall be required or allowed.
8. The drive shall have an emergency disconnect button pre-wired to the assembly.

C. Hoseless Collector Assembly

1. The hoseless solids collector assembly shall be manufactured entirely of stainless steel, with the exception of non-metallic parts such as casters, bushings, orifices, etc. which will be manufactured of plastic, non-metallic materials.
2. Each Hoseless collector assembly shall consist of four solids collection header pipes each equal to half the width of the basin. Each header pipe shall have helical flow orifice blocks spaced by the manufacturer to insure proper distribution across the length of the header. Each header pipe shall have removable end caps for easy clean out.
3. The helical flow orifice blocks shall be designed to cause flow to enter tangentially into the header pipe for more efficient solids removal. Orifices shall cause a spiral flow inside the header pipe to prevent solids from settling and shall point forward to remove the settled solids ahead of the pipe as it travels down the basin. Holes drilled in the bottom of the header pipe shall not be allowed.
4. The collection chamber shall “telescope” over the smaller fixed solids conduit. Articulating pipes, flexible solids hoses, flexible hose joints, or swivel joints are not allowed.
5. The collection chamber shall be isolated against the horizontal telescoping pipe solids conduit by means of a UHMW bushing.
6. The horizontal telescoping pipe solids conduit shall include a UHMW flow balancing ring designed by CFD analysis to assure equal flow from the front and back solids collection headers.
7. Each header pipe shall be equipped with a plow blade which is triangular in shape and is equal in length to the header pipe, as shown on the Drawings. These plows will remove the settled solids that have accumulated at the ends of the basins.
8. The Hoseless collector assembly shall be guided by means of horizontal casters on the ends of the header pipes. Guide rails are not allowed.
9. Flow through the hoseless solids collector shall be controlled by a solids valve as directed by the collector control panel.
10. Stainless curbs shall be provided by the manufacturer as required between multiple units. Include all floor supports, mounting hardware and properly sized anchors.
11. Provide stainless steel end stops to be anchored to the basin floor at the header assembly’s end of travel

2.04 CONTROLS

A. Each sludge collector shall have its own control panel. The Collector Control Panels shall comply with the respective specifications in Division 26 and Division 40.

B. The motorized flow control valves associated with the solids collectors as shown on the Drawings shall be controlled from the Collector Control Panel. The Collector Control Panel shall provide solids valve open and close commands and shall receive an open and close signal from the valve actuator as well as a signal to indicate that the valve is in "remote" operation.

C. Collector Local Control Panel:
   1. Each Collector Control Panel shall include a programmable logic controller based on the Modicon M340 platform, with provisions for Modbus TCP connection.
   2. The Collector Control Panel shall arrive to the jobsite internally pre-wired ready to connect to each drive unit.
   3. The Collector Control Panel shall be powered by a three phase, 480 VAC circuit.
   4. Associated control equipment shall be rated 120 VAC and powered from the control panel. Provide 120 VAC control transformer for all 120 VAC controls.
   5. Control Panel shall include Schneider Electric Harmony HIM touch panel screen, model HMIST0735 series, or approved equal.
   6. In addition to that already listed herein the Collector Control Panel shall include the following:
      a. Real time clock for programmable run initiation.
      b. PLC with associated communication cables.
      c. Variable frequency drive (VFD) with Local/Off/Remote and manual speed control when in Local mode. The VFD's shall be sized based on constant torque and the full load amp rating of the drive motors. VFD's shall be per specification 26 29 23 and be compatible with motors specified in 43 05 21.
      d. Panel face with the features specified herein.
      e. Pilot devices as specified herein.
      f. Properly sized protective circuit breakers, surge suppression devices, terminal blocks, wireways, control relays, space heater and enclosure light.
   7. Provide the following connections for each solids collector to the Plant SCADA system:
      a. In Remote (dry contact in LCP for monitoring by remote PLC)
      b. Running (dry contact in LCP for monitoring by remote PLC)
      c. Solids Collector Alarm Remote Start or Call to Operate (dry contact in remote PLC to activate LCP)
      d. Medium speed indication (dry contact in LCP for monitoring by remote PLC)
      e. High speed indication (dry contact in LCP for monitoring by remote PLC)
      f. Common fault (dry contact in LCP for monitoring by remote PLC)

      Control devices shall be housed in an enclosure constructed per the requirements of Section 26 29 13 –Enclosed Controllers. It shall be the responsibility of the solids collector manufacturer to provide all of the necessary control hardware and components as required for a complete and functional control system.
   8. The Collector Control Panel shall include environmental controls to maintain the internal temperature of the control panel to the ambient temperature rating of the components installed within the control panel. This includes the VFD's.

2.05 SPARE PARTS

A. Provide the following spare parts:
   1. Two (2) Drive cable, See manufactures recommended lengths
   2. One (1) 1-pole relay
   3. One (1) 2-pole relay
   4. Two (2) 5/16-inch cable thimbles
   5. Four (4) 5/16- inch wire rope clips
   6. Five (5) shear pins
   7. One (1) spanner
   8. One (1) pulley
   9. Two (2) Delrin bushing

B. Spare parts shall be tagged and stored as specified in Section 01 66 00.

2.06 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Certification of factory acceptance testing.
   2. Motor Data Form 43 05 21-A
   3. Manufacturer's Installation Certification Form 43 05 11-A specified in paragraph 3.01
   4. Manufacturer's Instruction Certification Form 43 05 11-B specified in paragraph 3.03.
   5. Equipment Test Report Form in accordance with Section 01 99 90.

PART 3 EXECUTION

3.01 INSTALLATION

A. The solids collectors shall be installed as specified and in accordance with manufacturer's written recommendations. The manufacturer shall provide a factory-trained service technician to supervise installation and testing of all components. The installation and initial operation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 TESTING

A. After completion of installation, the collectors shall be completely tested to ensure compliance with operating requirements as specified and in accordance with the testing procedures in Section 01 45 20.

B. In addition to the requirements of 01 45 20, fill each floc/sed basin with water and operate the collector continuously at maximum speed for 48 hours. At no point in the operation shall the solids collectors cease to operate. If the mechanisms fail or cease to operate, or in the opinion of the Owner, the solids collectors should exhibit evidence of improper installation, immediately halt the test and remedy the problem. After completion of necessary repairs or adjustments, the tests shall be repeated. Failure to successfully complete the test in six attempts shall be considered sufficient cause for rejection.

3.03 TRAINING

A. minimum of 8 hours of training conforming to the requirements of Section 01 79 00 and the following shall be provided. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90. Training shall include instruction on field adjustments and shall include complete disassembly and subsequent reassembly of one mechanism.

END OF SECTION

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SECTION 46 61 11

FILTER UNDERDRAIN SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies an underdrain (air/water) drinking water filter system. The underdrain system consists of the collection of filtered water and uniform distribution of backwash water and air supply for backwash events.
   2. The Supplier/Contractor shall provide all labor, materials, equipment and incidentals required to furnish and install the filter underdrain system with nozzle systems and air distribution manifold as shown on the Drawings and as specified.
   3. The filter underdrain system shall include the filter underdrain nozzles, nozzle sleeves, forming panels, panel support columns, and air distribution manifold.
   4. This section includes computational fluid dynamics (CFD) modeling for the plenum and waterways as shown on the Drawings. The Supplier shall include a final report with recommendations for plenum opening dimensions for backwash hydraulics optimization.

B. Equipment List:

Item	Equipment No.
Dual Media Filters	Filters 1-6

1.02 RELATED SECTIONS

A. The specification sections listed below are an integral part of this equipment specification.
   1. Section 03 60 00 - Grouting
   2. Section 05 05 20 – Anchor Bolts
   3. Section 40 05 02.01 – Piping System Schedule, Process Air (Stainless Steel)
   4. Section 40 05 07– Hangers and Supports for Process Piping
   5. Section 40 05 23 – Stainless Steel Process Pipe and Tubing
   6. Section 46 61 13 – Filter Media (Sand and Anthracite)
   7. Section 46 61 19 – Wash Water Troughs

B. NSF International:
   1. Standard 61- Drinking Water System Components – Health Effects.

C. ASTM international (ASTM)
   1. A790-Standard Specification for seamless and welded Ferritic/Austenitic Stainless-Steel Pipe

1.03 SYSTEM DESCRIPTION

A. Physical Requirements:
   1. There are a total of 6 single cell filters with nominal internal dimensions of 29.50 ft long by 12.00 ft wide.
   2. The plenum height shall be 2.00 ft. A total of nine (9) rectangular waterway orifices (plenum openings) shall be cast into the wall from the plenum to the lower gullet as shown on the Drawings. Final orifice heights shall vary and be determined by the manufacture using CFD modeling to optimize hydraulic distribution of backwash water.
   3. Each filter shall be equipped with an air distribution manifold located in the plenum. The Supplier shall design and supply the air distribution manifold from the connection point as shown on the Drawings. The air distribution manifold shall be structurally and seismically supported per the project specifications.
   4. The filter underdrain and air distribution manifold shall be constructed to avoid blocking the waterways and flow from the backwash supply and the filtered effluent.

B. Design Requirements
   1. General:
      a. The filter underdrains shall be resistant to changes in head loss, flow uniformity, corrosion, and any other effects which would in time cause loss of efficiency or effectiveness of its operation.
      b. Design the filter underdrains to meet all requirements for delivery, storage, handling, installation, and operation.
   2. Flow Design Requirements
      a. Design filter nozzles to produce uniform air and water flows throughout the filter cell over the full range of backwash and air scour flow rates specified on the Drawings.
      b. The installed filter underdrain systems shall satisfy both of the following criteria for acceptable flow uniformity:
         1) Maldistribution of air and water flows during backwash, for specified flow conditions, shall not exceed:
            a) Plus or minus 5 percent of average gallons per minute per square foot (cubic meter per hour per square meter) of filter area.
            b) Plus or minus 10 percent of average standard cubic feet or air per minute per square foot (Normal cubic meter per hour per square meter) of filter area.
         2) Visual test shall reveal no evidence of maldistribution or disturbance of filter media.
         3) CFD modeling provided by the Supplier shall reveal no evidence of maldistribution of air and water flows during backwash. Modeling shall include analysis through the plenum openings and underdrain nozzles.
      c. In addition to the uniformity requirements specified above, the head loss through the nozzle systems for the backwash water shall be 21 to 25 inches of water when backwashing at 23.0 GPM/ft^2 of filter area, no exceptions.

d. The filter underdrain systems shall be furnished and installed to perform satisfactorily and as specified when operated under the following flow conditions:
   1) Down flow of filtered water at 3.9 to 6.9 gpm/ft^2.
   2) Upflow of backwash water 6 to 23 gpm/ft^2
   3) Upflow of scour air up to 5 scfm/ft^2.
   4) Upflow of combined scour air and backwash water at 4 scfm/ft^2 and 8 gpm/ft^2, respectively.
e. Design the air backwash header to distribute air across the risers to the plenum over the full range of normal air backwash flow rates plus or minus 10% of average standard cubic feet of air per minute.

3. Structural Design Requirements
   a. The filter underdrain systems, including the concrete false floors and related appurtenances, anchorage, and supports, shall be designed in accordance with ACI Standard 318 to safely withstand the specified loadings.
   b. The nozzle underdrain systems, when installed, shall be designed for an uplift force of 1,600 pounds per square foot.
   c. There shall be no leakage from the seals, joints, or gaskets at the design pressure at maximum backwash rates.
   d. The filter underdrain systems shall be designed to withstand a net downward loading of not less than 1,400 pounds per square foot to account for the weight of the media, and the in-service hydraulic loading, plus its own dead weight and the force of vertical seismic accelerations as specified in Section 01 73 24.
   e. Adequate safety factors to account for dynamic loading (such as during the initiation and termination of backwash) and seismic loads as specified in Section 01 73 24, shall be included in the design to account for any dynamic loading above and beyond that described above.
   f. The design shall adequately provide for all loads incurred during shipment, handling, and installation.

C. The filter underdrain system shall be designed and installed to ensure long term stability in its operating characteristics. It shall be resistant to changes in head loss, flow uniformity, and any other effects which would in time cause loss of efficiency or effectiveness in its operation.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. The equipment provided under this section shall be the product of a firm regularly engaged in the design and manufacture of filter underdrain systems for water treatment plants. The Supplier/Subcontractor shall be prepared to document the manufacturer's technical competence, skill, resources, and ability to complete the work specified herein. All documentation shall be submitted and reviewed prior to design, fabrication, and shipment of any component specified herein.
   2. Manufacturer shall utilize a quality control program in manufacturing of the equipment specified herein. If requested, provide letter or certificate documenting and detailing quality control program.

B. Unit Responsibility:
   1. The underdrain manufacturer shall be responsible for designing and furnishing a ready-to-install filter underdrain system which meets all flow and structural design requirements specified herein, including items covered in article 1.02.A. All filter underdrain system items specified herein shall be obtained from a single filter underdrain manufacturer, who shall be the source of the information for all equipment furnished pertaining to the filter underdrain system, regardless of the manufacturing source of that equipment. A completed, signed, and notarized Certificate of Unit Responsibility (Section 01 99 90-Form 43 05 11-C) shall be provided that covers the Underdrain System and the ancillary systems mentioned in Article 1.02.A

C. Installation and Testing Certification:
   1. All installation activities including grouting, joining, and otherwise installing the underdrain system shall be performed by personnel properly trained by a representative of the filter underdrain manufacturer. Supplier/Contractor shall provide certification from filter underdrain manufacturer stating that the entire filter underdrain system has been properly installed, properly aligned, successfully tested, meets all requirements for the specified performance under the conditions herein, and that the equipment is ready to be put into continuous service.
   2. Support column forms, nozzle inserts, nozzles, and any specialties required for installation such as special anchorage, leveling shims, temporary sealing caps, air scour header, shall be the products of a single Supplier.

1.05 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00:
   1. Certificate of Unit Responsibility 43 05 11-Form C, attesting that the Supplier/Contractor has assigned unit responsibility in accordance with the requirements of this section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Supplier/Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Supplier/Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

3. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Complete shop drawings showing details of fabrication, materials of construction, dimensions, weights, performance, and installation and leveling data of all items furnished under this section. This includes the grout mix design for grout below and between units, the stainless steel anchors and adhesive anchor system, pipe supports, and all materials related to the underdrain assembly.
5. Submit detailed drawings showing installation and assembly details including setting drawings, cast-in-place items, templates, and details for the installation of the anchorages. This shall include all requirements to interface the underdrain system with the filter box including grouting keys and pockets, dowels, support ledges and piers, and other anchorages.
6. Provide head loss data covering the range of design air and water flowrates specified, including air scour alone, water wash alone, combined air/water washing, and flow distribution calculations or modeling to substantiate compliance with the specified maldistribution limits. Head loss data shall indicate individual losses including gullet losses, primary orifice losses, and secondary orifice losses.
7. Provide structural design calculations, including the hold down system and pipe supports. Grout mix design, along with the full structural design calculations, shall be stamped by a Professional Engineer registered in the State of Utah.
8. Provide certification of compatibility of the underdrain system with the filter media specified in Sections 46 61 13.
9. Provide certification that all wetted parts and sealants in contact with the process water are NSF-61 certified for contact with drinking water.
10. Filter underdrain manufacturer certification for each filter per requirements of Part 1.04.C.
11. Manufacturer’s Warranty. Warranty shall be for a period of 1 year from date of substantial completion, unless standard warranty is for a longer term.
12. Proposed field-testing procedures and testing report.
13. Manufacturer’s detailed recommendations for installation, start-up, and proposed field testing procedures, to include a detailed, step-by-step plan with checklists for start-up, hydraulic, and air scour testing of each underdrain installation prior to installation of media including procedures prepared by the underdrain manufacturer.
14. Recommendations for short and long-term storage.
15. List of required spare parts and special tools along with unit pricing for each part.
16. All operation and maintenance information.

1.06 SHIPMENT, PROTECTION AND STORAGE

A. All materials and equipment shall be shipped, stored, handled and installed in such a manner as not to degrade quality, serviceability or appearance. The equipment shall be stored in a clean, dry location, free from construction dust, precipitation and excess moisture. Stainless steel materials shall be handled and stored to avoid potential damage or contamination with carbon steel. If stored for more than two weeks, the equipment shall receive all maintenance considerations required by the manufacturer for proper storage of the equipment.

B. The Supplier/Contractor shall be responsible for coordinating the shipment of supplies of materials and equipment specified herein. Coordination will be required during construction and startup and/or testing.

C. Store underdrains and specialties off the ground, under ultraviolet-resistant tarps or indoors from time of delivery on-site until final installation in the filters.

D. Replace underdrains and specialties damaged during storage and delivery.

E. Underdrains and specialties are subject to inspection at the Owner's request if visual evidence of damage is observed.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. The Engineer believes the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.
   1. Orthos Liquid Systems, Inc.
   2. Or approved equal

B. The manufacturer of the filter underdrain system shall be ISO 9001 certified.

2.02 MATERIALS

A. General:
   1. Materials used in the filter underdrain system shall conform to specified requirements unless more stringent requirements are specified by the underdrain supplier.

B. Grout:
   1. Non-shrink grout conforming to the applicable requirements of Section 03 60 00.
   2. All grout associated with the installation of the underdrains shall be non-shrink grout.
   3. Underdrain manufacturer shall certify compatibility between the underdrain material and the non-shrink grout.

C. Structural concrete:
   1. As specified in Section 03 30 00 – Cast-in-Place Concrete, except that coarse aggregate shall not be larger than ½-inch diameter and shall have a minimum strength of 5000 psi at 28 days.
   2. Concrete Reinforcement: As specified in Section 03 20 00 – Concrete Reinforcing

D. Metals:
   1. As specified in Section 05 50 00 – Metal Fabrications.
   2. All exposed (not embedded in concrete) or partially exposed metals, including but not limited to anchor bolts and anchorage, fasteners, washers, etc., shall be Type 316 stainless steel.

E. Grout Stops, Cover Plates, and Concrete Retaining Strips:
   1. Shall be high impact plastic, or polyvinyl chloride, properly keyed or mechanically restrained to prevent the strips from working loose with time.
   2. Shall also be completely sealed with caulking to prevent water, air, or grout from leaking around them.
   3. Plastics shall be high strength, completely inert, resistant to erosion, corrosion, and degradation from chlorine up to 150 mg/l, and suitable for use with backwash temperatures from 40 to 140 degrees Fahrenheit.

2.03 NOZZLE UNDERDRAIN SYSTEM

A. Support System:
   1. The false floor shall be made up of reinforced concrete cast in place over prefabricated reinforced concrete forming panels.
   2. The forms remain in place as the underside of the floor slab and provide preformed holes for locating and supporting the cast-in-place flow element sleeves.
   3. The false floor forms shall be installed onto support columns inside the filter cell, and onto support ledges along the perimeter walls of the filter cell. The ledges and columns shall be leveled to within plus or minus 1/8 inch before installing the false floor forms.
   4. Leveling shims shall be provided by the underdrain manufacturer.
   5. The support system shall adequately provide for both longitudinal and transverse flow under the false floor to ensure uniformity of flow distribution.
   6. The false floor and support columns shall be designed to the criteria specified under Structural Design Requirements.

B. Forming Panels:
   1. The forming panels shall be constructed of high impact polystyrene or Glass Reinforced Concrete (GRC).
   2. The forms shall become a permanent part of the finished false floor.
   3. Forms shall be designed to carry stresses due to the placement of concrete with a maximum deflection of 1/8-inch.
   4. The manufacturer shall provide pre-cut filler forms, as required, to close the area along the perimeter walls where a full form cannot fit.

C. Flow Nozzles and Sleeves:
   1. Nozzle Sleeves
      a. The false floor shall contain an array of plastic nozzle sleeves cast in the concrete, uniformly spaced as required to prevent maldistribution of flow, and designed to accept a nozzle sleeve which shall lock into place at each nozzle location.
      b. The nozzle shall contain a disposable seal which shall prevent concrete from passing through or fouling the threaded portion.
   2. Nozzle:
      a. Each media retaining underdrain nozzle shall be molded of NSF-certified polypropylene or plastic.
      b. Nozzles shall screw into the nozzle sleeves and shall have narrow, vertical slot openings in a screen section suitably sized for compatibility with the filter media and no larger than 0.40 mm.
      c. Nozzle slots shall be designed to prevent clogging from small particles.
      d. Nozzles shall be designed to collect filtered water during the filtration cycle, and uniformly distribute air scour and wash water during the backwash cycle without permitting media to enter the plenum.
      e. Nozzles shall be easily installed (screwed into) and removed from the top side of the underdrain.
      f. Nozzles shall not require epoxy or metal fasteners for installation.
      g. Nozzles shall be designed to allow the direct placement of filter media (as specified) on top of the nozzle.
      h. Each nozzle shall be designed to withstand the same loadings as the monolithic pour.
      i. Nozzle Tail Pipe:
         1) Each nozzle shall have a tail pipe to provide for the uniform distribution of air scour and backwash water.
         2) Each tail pipe shall include one air metering orifice for proper distribution of scour air at the rates specified herein.
         3) Each nozzle shall have a hole in the tail pipe so placed to bleed off trapped air in the plenum.
      j. The manufacturer shall supply torque and other installation instructions and requirements to account for the variation in temperature from installation to service and other effects that may cause the nozzles to loosen in service.

D. Air Header:
   1. The filter underdrain system manufacturer shall have the responsibility to design and provide the air distribution header.
   2. The air distribution system shall be generally comprised of a minimum Schedule 10 316 stainless steel header specially calibrated to evenly distribute air flow via properly located riser pipes to each underdrain lateral. Sufficient relative velocities shall be maintained in both the header and riser pipes to insure proper distribution of air. Air piping shall conform to requirements of Sections 40 05 02.01 and 40 05 23.
   3. The filter underdrain system manufacturer shall supply pipe supports in accordance with Section 40 05 07. All pipe supports shall be Type 316 stainless steel.

2.04 AIR DISTRIBUTION MANIFOLD

A. In each filter underdrain plenum, an air distribution manifold shall be provided and installed with main header and riser pipes sized by the manufacturer to deliver an evenly distributed air flow to the respective underdrain plenum.

B. The main header shall be 316 Stainless Steel, Schedule 10, and riser pipes shall be 316 Stainless Steel, Schedule 40, in accordance with the requirements of ASTM A790.

C. The manufacturer shall design the air distribution manifold to provide a uniform distribution of airflow through each underdrain system to meet the air flow design requirements specified.

D. The manufacturer shall design the air distribution manifold to clear the manifold of water at the beginning of the air scour operation to result in an evenly distributed air flow to the respective underdrain plenum at the air rates specified herein.

E. Air metering tubes shall extend vertically upward between nozzle tailpipes, terminating above the nozzle tailpipes, terminating above the nozzle air metering hole without creating an air knife (less than 67 feet per second) to the plenum ceiling. Air velocity in the metering tubes shall not exceed 130 feet per second.

F. The manufacturer shall design the air distribution manifold from the connection point, as indicated on the Drawings.

2.05 PLENUM OPENINGS

A. The plenum and gullet heights shall be as shown on the Drawings. Plenum openings width shall be as shown on the drawings. Plenum opening heights shall be as shown on the drawings ±2 inches. Underdrain Supplier shall provide a final report that includes recommendations for plenum opening height dimensions to meet the Design Requirements of Article 1.03.B
   1. The final report shall include CFD modeling of the waterways, plenum and nozzles for the following flow scenarios:
      a. water backwash as the maximum rate shown on the Drawings
      b. water backwash at the minimum rate shown on the Drawings
      c. air/water combined backwash at 4 gpm/ft^2 and 8 gpm/ft^2, respectively
      d. air/water combined backwash at 3 gpm/ft^2 and 10 gpm/ft^2, respectively
   2. Modeling shall include at a minimum three separate plenum opening scenarios:
      a. Baseline – all opening heights are equal
      b. Modified – opening heights vary with only 3 sequential openings the same height (e.g., openings 1,2 and 3 are 9”; openings 4,5, and 6 are 8”, etc.)
      c. Optimized – plenum openings optimized based on results from the first two scenarios.

2.06 SPARE PARTS

A. Spare parts shall be provided for each unit as follows:
   1. A complete set of spare nozzles (quantity sufficient for one complete filter).

PART 3 EXECUTION

3.01 INSTALLATION

A. General

1. Install the filter underdrain systems in strict accordance with the manufacturer's installation drawings and printed recommendations, and as manufactured and indicated on the Drawings.
2. Provide an underdrain manufacturer's field representative to inspect and supervise the installation and testing of the underdrain system. All costs of such inspection and supervision shall be borne by the Supplier/Subcontractor. Installation work shall comply fully with the underdrain manufacturer's installation details and recommendations to acceptably interface the filter underdrain system with all surrounding structures, including requirements for grouting keys and pockets, dowels, support ledges and piers, anchorage and the like.

B. Cleaning and Placement:

1. During installation, take all necessary precautions recommended by the underdrain manufacturer and as specified herein to ensure that the underdrain system and piping connected thereto is completely clean and free of any debris, dirt, or other foreign materials which could clog the underdrain system or interfere with flow. Backwash air and water piping shall be thoroughly flushed clean. Air piping shall be flushed with air only. All loose debris and dirt within the filter and gullet shall be removed by brooming down, vacuuming and water flushing. Care shall be taken as necessary to prevent grout, concrete or debris from intruding into any flow passages or ports and all such grout, concrete or debris shall be removed. As installation progresses, underdrain sections partially completed shall be protected with heavy building paper, masking tape, or other means to maintain cleanliness. Cleanliness shall be maintained until final placement of filter media.

C. Nozzle Underdrain System Installation:

1. The reinforced concrete false floor underdrain system shall be a monolithic, cast-in-place, concrete structural slab that shall be finished to a true level plane within the lesser of plus or minus 1/8 inch or the tolerance specified by the manufacturer of the filter underdrain.
2. Failure of the filter underdrain system to meet the level tolerance shall require removal of the failed sections and replacement with new underdrain sections to within level tolerances.
3. Should any underdrain materials, including the false floor forms, nozzle sleeves, and nozzles become chipped, plugged, bent, or damaged in any way, they shall be removed and replaced before the false floor is poured.

3.02 START-UP AND TESTING

A. General:
   1. The equipment provided under this section shall be started up and tested only under the direction of the underdrain supplier. To that end, the underdrain equipment manufacturer shall furnish start-up and testing specialist(s) that has been factory trained in the proper procedures for initial installation, testing, and commissioning of the equipment. All such activities shall be performed under the direction of these specialist(s).
   2. The underdrain system manufacturer shall provide a technical representative to assist with the startup for not less than 16 working days (8 hours per day) in a minimum of 4 trips. Travel time shall not be included within the 8 hours per day.
      a. The factory service technician shall have a minimum of five (5) years' experience in the startup of air/water filter backwash systems.

B. Preliminary Structural Integrity Test:
   1. Perform this test after sufficient curing time of 28 days has elapsed to permit the installation to develop adequate strength for dynamic testing and before the placement of any media.
   2. Flood filter cell with approximately one foot of clean water above the underdrain.
   3. Backwash each underdrain installation increasing the backwash rate in stages as follows:
      a) 6 gpm/ft^2
      b) 15 gpm/ft^2
      c) 23 gpm/ft^2 (maximum backwash rate)
      d) Hold rate at each stage for a sufficient observation period as determined by the Owner's Representative.
   4. During this test, flow from each nozzle as well as any sign of dead spots or boils shall be visually observed. Any evidence of flow maldistribution such as a water "mound" or "boil" in any area of the filter will constitute a failed test.
   5. After this initial test, the filter shall be drained, and the underdrain system shall be inspected for any damage or leaks.
   6. Correct any damage or deficiencies revealed by these tests.
   7. Repeat test after damages are repaired and until deficiencies are corrected at no additional cost to the Owner.

C. Underdrain Flow Distribution Test:
   1. This test shall be performed after the Preliminary Structural Integrity Test and before the media is placed.
   2. Flood filter cells with clean water approximately 6 inches above the underdrain at the beginning of each test. Sustain test flow rates for approximately 3 minutes while making visual observations.
   3. Extend or repeat test when additional time is needed to make observations, as directed by the Engineer.

4. Tests shall be as follows:
    a. Test 1 – 4 scfm/ft^2 of scour air with no backwash water
    b. Test 2 – 4 scfm/ft^2 of scour air with 6 gpm/ft^2 of backwash water
5. During each test, the water surface shall present a uniformly turbulent appearance without dead spots or boils. Any evidence of flow maldistribution will constitute a failed test.
6. Correct and retest underdrain systems that fail to meet the test criteria.
7. Repeat tests after damages are repaired and until deficiencies are corrected at no additional cost to the Owner.

D. Equal Distribution Test of Backwash Water (Manometer Test)
1. The demonstration must be completed before the installation of media.
2. Since pressure is directly related to flow in a flooded filter, this test measures the pressure in the plenum during a backwash. To measure the pressure, the Contractor shall install seven (7) Supplier-provided piezometric adapters in the false floor as indicated on the plans. Four adapters shall be placed near each corner of the filter and three across the centerline of the filter from the backwash entrance(s).
3. From the piezometric adapters on the nozzle sleeves, the Contractor shall route Supplier-provided transparent vinyl tubing of equal length from the installed piezometric adapters to a Supplier-provided piezometer panel that contains a scale for each sample tube. Contractor to adjust the panel and the scales with the water level during backwashing and assist with measurements as directed by the Supplier.
4. The panel shall be installed in a place far from the troughs. Figure 3.24 of "Filter Troubleshooting and Design Handbook" by R.P. Beverly of the AWWA shall serve as a reference for performing this test.
5. Pressure readings representing the pressure drop of the underdrain are measured as the height of the water in each tube above the wash water level during a backwash.
6. Testing shall be performed at 23 gpm/ft^2 of backwash water.
7. The test shall demonstrate equal distribution of the backwash water. A maldistribution variation of up to ± 5% between different measurement points is acceptable. If the variation is found to be greater than ± 5%, the CONTRACTOR must make all corrections required to meet the maximum prescribed variation. No work will be allowed in any subsequent filters until the problem is corrected.
8. The measurements shall be recorded by the Supplier, and a report shall be submitted to the Owner Representative for review.

E. Sand Flow Distribution Test:
1. After the underdrain systems have been installed and have passed the Equal Distribution Test of Backwash Water, the filter sand media may be placed.
2. The Sand Flow Distribution Test for each filter may occur in conjunction with the sand washing and skimming procedure as described in the Filter Media Section, but before placement of Anthracite filter media.
3. Sand Flow Distribution Tests shall consist of at least 3 backwash cycles and shall be as follows:
    a. Prior to testing, to measure the levelness of the sand surface, measure the distance from an elevation above the media down to the sand surface for a minimum of (7) locations.

b. Flood filter cell approximately 6 inches above the sand media with clean water.
c. Air scour at 4 scfm/ft^2 for 4 minutes.
d. Simultaneous air and water backwash at 4 scfm/ft^2 and 6 gpm/ft^2, respectively, for 4 minutes.
e. Water backwash at 23 gpm/ft^2 for 4 minutes.
f. Water backwash at 6 gpm/ft^2 for 4 minutes.
g. Drain down to initial level and repeat.
h. At the conclusions of the 3 backwash cycles, inspect the sand surface.

4. Results:
a. Variation more than plus or minus 1/2 inch from the average level plane indicates failure.
b. Media boiling shall constitute a failed test.
c. Media movement from one area of the filter to the other shall constitute a failed test.
d. Follow underdrain manufacturer's specific instructions necessary to correct any deficiencies revealed by these tests
e. Repeat tests until deficiencies are corrected at no additional cost to the Owner.

F. Anthracite Flow Distribution Tests:
1. After the Sand Flow Distribution Test and removal of all sand fines, the Anthracite media may be placed.
2. The Anthracite Flow Distribution Test for each filter may occur in conjunction with the Anthracite washing and skimming procedure as described in the Filter Media Section.
3. Anthracite Flow Distribution Tests shall consist of at least 3 backwash cycles and shall be as follows:
a. Prior to testing, to measure the levelness of the sand surface, measure the distance from an elevation above the media down to the Anthracite surface in (7) different locations.
b. Flood filter cell approximately 6 inches above the Anthracite media with clean water.
c. Air backwash at 4 scfm/ft^2 for 4 minutes.
d. Simultaneous air and water backwash at 4 scfm/ft^2 and 6 gpm/ft^2 respectively, for 4 minutes.
e. Water backwash at 23 gpm/ft^2 for 4 minutes.
f. Water backwash at 6 gpm/ft^2 for 4 minutes to re-stratify the media.
g. Drain down to initial level and repeat.
h. At the conclusions of the 3 backwash cycles, inspect the Anthracite surface.
4. Results:
a. Variation more than plus or minus 1/2 inch from the average level plane indicates failure.
b. Media boiling shall constitute a failed test.
c. Media movement from one area of the filter to the other shall constitute a failed test.

5. Follow underdrain manufacturer's specific instructions necessary to correct any deficiencies revealed by these tests.
6. Repeat tests until deficiencies are corrected at no additional cost to the Owner.

G. Final Underdrain Inspection:
1. After the Flow Distribution Test(s), the filter shall be completely drained, and the underdrain system shall be inspected for indication of media passage through the underdrain system or media deposition inside/below the underdrain. Such indication of media shall constitute a failed inspection.
2. Follow underdrain manufacturer's specific instructions necessary to correct any deficiencies revealed by this test.
3. Repeat tests until deficiencies are corrected at no additional cost to the Owner

H. Notify the Engineer at least 2 days in advance of planned testing to enable Engineer to witness the tests.

3.03 TRAINING

A. Furnish services of qualified factory trained specialists from underdrain manufacturer to instruct Owner’s operations and maintenance personnel in recommended operation and maintenance of the products. Training requirements, duration of instruction, and other qualifications shall be per Section 01 79 00.

3.04 SYSTEM WARRANTY

A. Guarantee/Warranty: Warranty shall be for a period of 1 year from date of substantial completion, unless standard warranty is for a longer term. Provide the longer of 1 year, or standard warranty.

END OF SECTION

SECTION 46 61 13

FILTER MEDIA

PART 1 GENERAL

1.01 SUMMARY

A. Supply and installation of filter media in each of six filters as specified herein. Each filter consists of one cell (6 cells total). Each cell is approximately 29.5 feet long by 12 feet wide. The finished media depth after skimming consists of 54 inches of anthracite above 12 inches of sand. Contractor shall verify all required dimensions prior to purchasing and installation.

B. Media Responsibility: The Media Supplier has sole responsibility for furnishing granular filter media meeting the requirements of the specification.

C. Work Restrictions: The contract documents contain limitations on work schedules, media removal, and backwash limitations.

D. Related sections:
   1. Section 01 75 70 – Disinfection.
   2. Section 46 61 11 – Filter Underdrain Equipment

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AWWA B100	Filtering Material
ASTM C40	Test Method for Organic Impurities in Fine Aggregates for Concrete.
ASTM C117	Test Method for Materials Finer Than 75-um (No. 200) Sieve in Mineral Aggregates by Washing.
ASTM C123	Test Method for Lightweight Particles in Aggregate
ASTM C127	Test Method for Specific Gravity and Absorption of Coarse Aggregate.
ASTM C128	Test Method for Specific Gravity and Absorption of Fine Aggregate.
ASTM C136	Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM C702	Standard Practice for Reducing Samples of Aggregate to Testing Size.
ASTM D75	Practice for Sampling Aggregates
ASTM D388	Standard Classification of Coal by Rank
ASTM D409	Test Method for Grindability of Coal by the Hardgrove-Machine Method.
ASTM D3174	Test Method for Ash in the Analysis Sample of Coal and Coke from Coal.
ASTM D3175	Test Method for Volatile Matter in the Analysis Sample of Coal and Coke.
ASTM E11	Specification for Wire Cloth and Sieves for Testing Purposes.
FCC	Food Chemical Codex
NSF 61	Standard 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Particle size distribution:
   1. The particle size distribution shall be determined by screening through standard sieves, Tyler fourth root of two series or equivalent U.S. series.
   2. The percent sizes shall be determined from a plot, on semi-log or probability paper, of the percentages of the material passing each sieve against the calibrated opening of the sieve or the equivalent diameter of the grains. Sieve dimensions shall conform to ASTM E11 and Table B.1 of the Appendix to AWWA B100.

B. Percent Size: The size of the theoretical opening of a sieve through which that percentage of the filter media, by weight, will pass.

C. Effective Size: The size opening that will just pass 10 percent (by dry weight) of a representative sample of the filter material. For example, if the size distribution of the filter media particles is such that 10 percent of the sample is finer than 0.50 millimeters, the filter media shall be said to have a 10 percent size of 0.50 millimeters, which is the effective size in millimeters.

D. Uniformity Coefficient: A ratio calculated as the size opening that will just pass 60 percent (by dry weight) of a representative sample of the filter material, divided by the size opening that will just pass 10 percent (by dry weight) of the same sample.

E. Media Supplier: The Media Supplier is the company or firm having sole responsibility for all granular media furnished and is either the manufacturer of the sand media or the anthracite media. The Media Supplier is responsible to furnish sand and anthracite media that are compatible with each other under backwash conditions.

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, and those listed within this section with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote them with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Sufficient cause for rejection of the entire submittal with no further consideration is failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal.
   4. Completed Certificate of Unit Responsibility attesting that the Contractor has been assigned, and that the manufacturer accepts unit responsibility in accordance with the requirements of this section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

5. Complete Media Analysis.
    a. Sand quality information:
        1) Sieve analysis (particle size distribution), effective size, and uniformity coefficient.
        2) Acid solubility.
        3) Apparent specific gravity.
        4) Hardness based on the Mohs scale.
    b. Anthracite quality information:
        1) Sieve analysis (particle size distribution), effective size, and uniformity coefficient.
        2) Acid solubility.
        3) Apparent specific gravity.
        4) Hardness based on the Mohs scale.
        5) Ash content (ASTM D3174).
        6) Volatiles content (ASTM D3175).
        7) Grindability Index (ASTM D409).
6. Any other information as requested by the OWNER.
7. Submit qualifications of the independent testing laboratory for approval.
8. Media Submittal: For each type of media submit the following.
    a. Media Benchmark.
        1) Purpose: To establish the agreed upon benchmarks for the material that is to be manufactured.
        2) Schedule: Submittal approval is required prior to beginning manufacturing.
        3) Requirement:
            a) Certified test results of complete media analysis (1.04.B), from an approved independent testing lab employed by the Media Supplier, for the proposed media.
            b) Media Samples:
                (1) Submit one sample of each type of media.
                (2) Shipped in durable, non-glass containers of not less than 5 lb capacity, clearly labeled with Project name, media source, effective size, uniformity coefficient and specific gravity.
                (3) OWNER reserves the right to retest (at OWNER's expense) the samples to confirm that the samples reasonably match certified test results submitted.
    b. Manufactured Media Testing and Samples.
        1) Purpose: To demonstrate that media produced during the manufacturing process is reasonably similar to the approved benchmark submittal.
            a) It is anticipated that there may be a reasonable variation in the effective size and uniformity coefficient between different media lots produced during the manufacturing process for the Project.
                (1) A media lot is defined as media continually produced during a work day. Media produced on different days or after changes to the production equipment shall be considered separate lots.

b) Although such variation may be acceptable, the OWNER reserves the right to use the test results to direct the CONTRACTOR to install individual production lots of sand and anthracite media in different filters to provide the best possible media compatibility matches at no additional cost to the OWNER.

c) OWNER may reject any or all individual media lots produced during the manufacturing process that do not meet the requirements of the specification. Rejected lots will not be shipped to the Project site without additional remanufacturing or reprocessing and subsequent approval of test results by the OWNER.

2) Schedule:

a) Media samples and test result approval is required prior to shipping.

b) Separate submittals for individual production lots are required for large media quantities involving production runs over an extended duration. It is anticipated that individual lot test results will be submitted to the OWNER as soon as they are available during the production of media.

3) Requirement:

a) Filter media lots shall be sampled and tested for effective size and uniformity coefficient. The media producer may use in-house testing capabilities or an independent laboratory for the manufactured testing, but only after laboratory acceptance and approval by the OWNER.

b) Sample collection and frequency for individual production lots shall be in accordance with AWWA B100 and as modified herein. All test results shall be identified by traceable production lot identification clearly marked on each bag.

c) Manufactured Media Samples:

(1) Submit one sample of each production lot and type of media.

(2) Sample collection in accordance with AWWA B100.

(3) Shipped in durable, non-glass containers of not less than 5 lb capacity, clearly labeled with Project name, media source, effective size, uniformity coefficient and specific gravity.

(4) OWNER reserves the right to retest (at OWNER's expense) the samples to confirm that the samples reasonably match certified test results submitted.

c. Delivered Media Testing.

1) Purpose: To demonstrate that media delivered to the Project site matches the manufactured media.

a) The OWNER reserves the right to test the media received at the Project site at the OWNER'S expense.

b) Media that does not comply with the specified requirements, certified test results, or acceptance criteria may be rejected at the sole discretion of the OWNER and shall be replaced with approved media at no additional cost to the OWNER.

c) If the delivered media is rejected by the OWNER, an independent laboratory, acceptable to the OWNER, may be employed by the CONTRACTOR to sample and test disputed material. For material that is not in compliance with the specified requirements, the CONTRACTOR shall bear the cost of testing the delivered media and any retesting required by the OWNER to demonstrate compliance. Otherwise, the OWNER is responsible for costs of testing the delivered media.

2) Schedule: After delivery to the Project site and before installation.

3) Requirement:

a) Sample collection in accordance with AWWA B100.

b) Test results provided by an independent lab, acceptable to the OWNER.

d. Installed Media Testing.

1) Purpose: To document the characteristics of the installed media in each filter for the use of the OWNER in tracking changes in media characteristics over time and to assess the impacts of the backwash/skimmer procedure. It is understood that the effective size and uniformity coefficient of the installed media, after washing and skimming, may differ from values prior to installation.

2) Schedule:

a) Sand media shall be sampled after complete installation, washing and skimming of all sand layers to the required depth and prior to the installation of anthracite media.

b) Anthracite media shall be sampled after complete installation, washing and skimming of all anthracite layers to the required depth.

3) Requirement:

a) Collect media samples using a clean trowel or sampling tube to provide a representative sample from the entire media depth.

b) Store samples in clean clear plastic bags, securely sealed and labeled with location, media type and collection date using indelible marker.

c) Provide test results of effective size, uniformity coefficient and specific gravity for each sample.

d) Sampling Locations:

(1) One representative, composite sample collected from five locations including one in the center and one from each quarter quadrant of the cell.

(2) Sampling and testing is the responsibility of the CONTRACTOR using a laboratory approved by the OWNER.

9. Submit media installation instructions from the Media Supplier.

1.05 QUALITY ASSURANCE

A. Certified test results shall cover all physical, gradation, size, and chemical characteristics specified herein. All tests shall be made in accordance with test procedures as described in AWWA B100.

B. After approval, all shipments delivered to site shall meet the specifications. Approved samples shall meet the requirements of AWWA B100 including any addenda.

C. As bags are being filled at the production site, sampling across the cross section of material being loaded for each lot is required. Each package and container shall be legibly marked per AWWA B100.

D. Sampling and testing shall be performed in accordance with the requirements of AWWA B100.

E. The sand media and anthracite media manufacturing plants are to provide documentation that their respective site-specific manufacturing facilities are independently certified to be in compliance with the NSF/ANSI 61 Standard

1.06 PRODUCT HANDLING, STORAGE, AND DELIVERY

A. Packaging: Package filter media in 1 to 2 ton capacity, ultraviolet-resistant polyethylene bags (super sacks with bottom pour spout) on pallets. Clearly mark each bag of material with the following information:
   1. Effective size.
   2. Uniformity coefficient.
   3. Source.
   4. Date of bagging.
   5. Production lot or stockpile identification.

B. Place or store all filter media only in designated staging areas approved by the OWNER.

C. All filter media at the jobsite shall be stored off the ground, protected from weather, and covered with a suitable membrane to prevent contamination of the media from windblown debris and soil.

D. Conveying of the new filter media by compressed air through ducts, pipes, or hose is not permitted. Placement of filter media in the filters shall comply in all respects with AWWA B100, except as modified or supplemented herein.

PART 2 PRODUCTS

2.01 FILTER SAND

A. Quality:
   1. The filter sand shall be silica sand composed of hard, durable, uncoated grains. The filter sand shall be thoroughly washed, screened, and free of clay, loam, dust, dirt, organic matter, and other foreign material.
   2. The acid solubility of the filter sand shall not exceed 1.0 percent.
   3. The specific gravity of the filter sand shall not be less than 2.60.

B. B. Size:
   1. The silica sand shall meet the following requirements:
      a. Effective size (millimeters): 0.65 (±0.05).
      b. Uniformity coefficient: less than 1.40
      c. Final depth (inches): 12
      d. A maximum of 1% retained on a U.S. #14 Sieve (1.40 mm)

e. A maximum of 1% passing a U.S. #40 Sieve (0.425 mm)

2. Provide sufficient excess sand media to anticipate the skimming requirement, such that after skimming is completed to the specified criteria, the media is at the depth indicated in this specification.

2.02 FILTER ANTHRACITE

A. Quality:

1. The anthracite shall be composed of hard durable grains and shall be processed from anthracite coal. The anthracite shall be free from any significant amounts of iron sulfides, clay, shale, dust, dirt, or other foreign matter.
2. The solubility of the filter anthracite in a 1:1 mixture of concentrated hydrochloric acid (approximately 37 percent) shall be less than 1 percent. The solubility of the filter anthracite shall be less than 1 percent by weight in 1 percent hot (190 degrees Fahrenheit) sodium hydroxide solution.
3. The filter anthracite shall have a hardness of not less than 3.0 on the Mohs scale.
4. Average apparent specific gravity shall be determined by the procedure set forth in ASTM C128, which provides for soaking the sample in water for 24 hours. The filter anthracite shall have a specific gravity of not less than 1.60, nor more than 1.70.
5. The filter anthracite shall have an ash (dry) content of less than or equal to 15 percent as determined by ASTM D3174.
6. The filter anthracite shall have a volatiles (dry ash free) content of less than or equal to 7 percent as determined by ASTM D3175.
7. The filter anthracite shall have a Hardgrove grindability index of less than or equal to 38 as determined by ASTM D409.

B. Size:

1. The anthracite shall meet the following requirements:
   a. Effective size (millimeters): 1.2 (±0.05).
   b. Uniformity coefficient: less than 1.35.
   c. Final depth (inches): 54
   d. A maximum of 1% retained on a U.S. #10 Sieve (2.00 mm)
   e. A maximum of 1% passing a U.S. #25 Sieve (0.71 mm)
2. Provide sufficient excess anthracite media to anticipate the skimming requirement, such that after skimming is completed to the specified criteria, the media is at the depth indicated in this specification.

2.03 MEDIA COMPATIBILITY

A. The Media Supplier shall provide filter sand media and anthracite media that are compatible when backwashed. Media compatibility between sand and anthracite shall be determined from the following formula:

$Q_{BW}=17.67 \times d_{60} (S.G.-1.0)^{2/3}$

Where:

Q_{BW} = media backwash rate in gpm/ft^2

D_{60} = effective size in millimeters multiplied by uniformity coefficient

S.G. = apparent specific gravity

B. The Q_{BW} calculated for the sand media shall be greater than or equal to the Q_{BW} calculated for the anthracite media, but not more than 2.0 gpm/ft^2 greater.

C. Due to the variability and physical nature of media size, uniformity coefficient, and apparent specific gravity, and as necessary to improve results for media compatibility, the Media Supplier shall produce either the sand or anthracite media first to establish the backwash characteristics of that media and shall then produce the second media to match the backwash compatibility of the first.

2.04 ACCEPTABLE MEDIA SUPPLIERS

A. Carbonite

P.O. Box 1
Delano, PA 18220
Telephone: (570) 467-3350
Website: carbonitecorp.com

B. CEI

28205 Scippo Creek Rd.
Circleville, OH 43113
Telephone: (800) 344-5770
Website: www.ceifiltration.com

C. F.B. Leopold Company, Inc

227 S. Division St
Zelienople, PA 16063
Telephone: (724) 452-6300
Website: www.xylem.com/en-us/brands/leopold/

D. Red Flint Sand and Gravel, LLC

615 Short St.
Eau Clair, WI 54701
Telephone: (800) 238-9139
Website: www.redflint.com

E. Unifilt Corporation

P.O. Box 614
Ellwood City, PA 16117
Telephone: (800) 223-2882
Website: www.unifilt.com

F. Approved equal.
   1. In order to be approved as an equal, a prospective Media Supplier shall submit the following:
      a. Documentation demonstrating that the supplier has been continuously engaged in the business of manufacturing either sand or anthracite filter media for potable water treatment plants for a period not less than five years.
      b. References for a minimum of five similar projects for which the supplier has successfully furnished either sand or anthracite filter media within the last 10 years. Similar projects are defined as potable water treatment plant filters of equal or greater size to those of the Project.
      c. A letter signed by an authorized officer of the company certifying that the supplier will comply with all requirements of the specification including the requirement to accept sole responsibility for all filter media and to provide compatible sand and anthracite media as specified.
      d. Documentation that the site-specific manufacturing facilities are in compliance with the latest version of the ANSI/AWWA B100 Standard and are independently certified with the NSF/ANSI 61 Standard
   2. Approval of a prospective Media Supplier is at the sole discretion of the OWNER.

PART 3 EXECUTION

3.01 FILTER MEDIA INSTALLATION

A. Before placing filter media:
   1. Verify that all openings of the filter underdrain media retaining devices are clean and free of obstructions, and that the area around the filter underdrains is swept clean and vacuumed.
   2. Remove all debris from filters.
   3. Thoroughly wash down all parts of the filter units with clean water.
   4. Maintain the cleanliness of the filters throughout the media placement operation.
   5. The underdrain system shall pass a flow distribution test before any media is placed. The underdrain is considered to have passed this test upon the OWNER's acceptance of the test results.
      a. Place six inches of water over the filter underdrain. Observe water entering the filter and check for maldistribution indicating either a plugged or broken cap/nozzle.
      b. Perform an air scour at the normal plant air scour rate. Observe the air scour and check for maldistribution indicating either a plugged or broken cap/nozzle.
   6. Perform backwash at the normal plant backwash rate. Observe the backwash and check for maldistribution indicating either a plugged or broken nozzle.

B. Media Placement - General
   1. Prevent contamination during transporting and placing the filter media. Any filter media which has become contaminated, either before or after placement in the filters, shall be removed and replaced with new or washed and cleaned material in a manner approved by the OWNER.
   2. Based upon submitted test results of manufactured media and media matching parameters, the OWNER reserves the right to use the test results to direct the CONTRACTOR to install individual production lots of sand and anthracite media in different filters to provide the best possible media matching compatibility at no additional cost to the OWNER.
   3. Each layer of filter media shall be brought up to the required elevation and made level over the entire filter bed area. Provide sufficient excess media to anticipate the skimming requirement, such that after skimming is completed the media is at the depth indicated in this specification.
   4. The placement of each media layer shall be accepted by the OWNER before the next layer is placed.
   5. Do not damage any equipment or piping in the filter units. Bring any damage to the attention of the OWNER and repair said damage in a fashion acceptable to the OWNER.
   6. Workers shall not stand or walk directly on the filter materials. The workers shall walk on plywood mats that will sustain their weight without displacing the material (minimum dimensions 2 feet by 2 feet by 1/2 inch thickness).
   7. The filter may be flooded with water to use as a leveling gauge for each layer of material.
   8. Each media level shall be thoroughly washed and skimmed (by scraping) for removal of fine grain-sized particles before the next layer is placed.
   9. Place each layer evenly throughout the filter. Do not place in one area and then spread to the rest of the filter. Initial placement shall include sufficient depth to account for skimming and removal of media and fine particles.

C. Media Washing - General:
   1. The CONTRACTOR is responsible for coordinating the scheduling of filter media washing with the OWNER and ENGINEER to avoid delays to the schedule.
   2. Filter media washing will be conducted with clean water using backwash supply, auxiliary wash facilities, and waste washwater facilities as designed and configured as part of the existing plant or new plant construction.
   3. At no time shall the plant's wash water handling facility overflow from the media washing operations. Filter media washing shall be terminated before reaching a water level that would affect plant operations regardless of the status of the media washing operation.
   4. Make certain that water from the media washing operation is directed to the washwater handling facilities and does not flow to the storm drain or to discharge off-site.
   5. Verify separation of the media washing residuals from the backwash water sufficient for returning the water to the treatment plant. Remove and dispose of the residuals from the media washing operation.

D. Filter Sand:

1. Before placing the sand, remove all plywood panels used by the construction personnel to walk on the media support system or on the filter media. Fill the filters to a water depth 12 to 15 inches above the surface of the filter media support system. The sand shall then be placed into the water in a uniform manner over the entire surface area of the filter. This may require hand placement of the initial layer of filter sand.
    a. Transport and place the sand carefully to prevent contamination of any sort, and replace sand made dirty before or after placing with clean sand.
    b. Any indication during sand placement that the underdrain has been displaced or damaged shall require the sand to be removed and the underdrain repaired or replaced in accordance with the underdrain manufacturer's specific instructions for repairing damage.
2. After placing the filter sand, backwash the filter at an initial rate of not more than 2 gallons per minute per square foot (gpm/ft^2) of filter area and increase the rate gradually over a period of 3 minutes to a maximum rate of 20 gpm/ft^2, or as directed by the OWNER. Maintain this maximum rate for a minimum of 5 minutes, and until waste washwater appears clear. Close the filter backwash rate valve slowly to allow for hydraulic media segregation. This backwash sequence, or similar sequence as directed by the OWNER, shall be conducted before each skimming.
3. Using hand trowels and laser level, skim the top surface of the media to remove all fine-grained sized materials. Dispose of the sand particles removed by skimming.
4. At the discretion of the OWNER, skimming that is not of uniform depth shall be redone.
5. Conduct filter sand washing and skimming operations described above three separate times as follows:
    a. Wash and Skim No. 1: Depth of skimming and removal shall be a minimum of ½".
    b. Wash and Skim No. 2: Depth of skimming and removal shall be a minimum of ½".
    c. Wash and Skim No. 3: Skim and remove media to final depth. (Remove approximately 1/4" of media.)
6. After final skimming operation is finished, wash the media a final time as described above, drain the filter and measure final depth. Measured final depth shall not be less than 1/4" nor greater than 1/2" from the requirement. Otherwise, add or remove media and repeat washing and skimming as directed by the OWNER.
7. Upon approved completion, collect and test representative sand media sample from the filter in accordance with Paragraph 1.04 of these specifications. Test results shall be submitted to the OWNER. If OWNER determines additional skimming is required, CONTRACTOR shall repeat the entire backwash/skimming procedure described in this section one additional time at no additional cost to OWNER. Contractor shall initially purchase enough material to accomplish all six rounds of skimming.

E. Filter anthracite:

1. Remove all plywood panels used by the construction personnel to walk on the media before placing any anthracite. Transport and place the anthracite carefully to prevent contamination of any sort, and replace anthracite made dirty before or after placing with clean anthracite. Do not place anthracite filter media in any filter cell until the filter sand in that cell has been skimmed to final depth and accepted.
2. After placing the filter anthracite and soaking it in clean water in the filter box for 24 hours, backwash the filter media at an initial rate of not more than 2 gpm/ft^2 of filter area and increase the rate gradually over a period of 3 minutes to a maximum rate of 20 gpm/ft^2, or as directed by the OWNER. Maintain this maximum rate for a minimum of 5 minutes and until the waste washwater becomes clear. Close the filter backwash rate valve slowly to allow for hydraulic media segregation. This backwash sequence, or similar sequence as directed by the OWNER, shall be conducted before each skimming.
3. Using hand trowels and laser level, skim the top surface of the media to remove all fine-grained sized materials. Dispose of the anthracite particles removed by skimming.
4. At the discretion of the OWNER, skimming that is not is not of uniform depth shall be redone.
5. Conduct anthracite media washing and skimming operations described above three separate times as follows:
    a. Wash and Skim No. 1: Depth of skimming shall be approximately 3/4".
    b. Wash and Skim No. 2: Depth of skimming shall be approximately 1/2".
    c. Wash and Skim No. 3: Skim and remove media to final depth (Remove approximately 1/4" of media.).
6. After final skimming operation is finished, wash the media a final time as described above, drain the filter and measure final depth. Measured final depth shall not be less than 1/4" nor greater than 1/2" from the requirement. Otherwise, add or remove media and repeat washing and skimming as directed by the OWNER.
7. Upon approved completion, collect and test representative anthracite media sample from the filter in accordance with Paragraph 1.04 of these specifications. Test results shall be submitted to the OWNER. If OWNER determines additional skimming is required, CONTRACTOR shall repeat the entire backwash/skimming procedure described in this section one additional time at no additional cost to OWNER. Contractor shall initially purchase enough material to accomplish all six rounds of skimming.

3.02 DISINFECTION

A. Before the filter is placed in service, the entire filter shall be disinfected by chlorination as specified in Section 01 75 70.

B. Allow at least 24 hours for disinfection of a filter.

3.03 CLEANING

A. Filter structure cleaning: Once all filter testing and skimming operations are completed, remove all debris and media from all backwash drain conduits, troughs, pipelines and structures. General

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SECTION 46 61 15

FILTER WASHWATER TROUGHS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies the fiberglass-reinforced plastic (FRP) washwater troughs for the filters. FRP troughs shall be designed, furnished, and installed complete and serviceable as shown and specified herein to make the work complete and operable. All supports, anchors, fasteners, and accessories shall be included.

1.02 RELATED SECTIONS

A. The specification sections listed below are an integral part of this equipment specification.
   1. Section 05 05 20 – Anchor Bolts

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall maintain a continuous quality control program in the manufacturer of materials specified herein.
   2. Manufacturer shall have experience in manufacturing troughs of the same material, and the same or larger size to the items specified.
   3. Manufacturer shall provide evidence of filter washwater troughs in a similar service and of the same type specified for a minimum of ten installations, each in satisfactory operation for a minimum of five years.

B. All items specified under this Section shall be obtained from a single manufacturer who, with the Supplier/Subcontractor, shall assume full responsibility for the completeness of the system. The manufacturer shall be the source of information on all equipment furnished regardless of the manufacturing source of that equipment.

C. Reference Standards:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to the documents in this section shall mean the documents in effect at the time of Bid. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA F101	Contact-Molded, Fiberglass-Reinforced Plastic Wash Water Troughs and Launders
AWWA F102	Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets
ASCE 8	Specification for the Design of Cold-Formed Stainless Steel Structural Members
ASTM D 256	Standard Test Methods for Determining Izod Pendulum Impact Resistance of Plastics
ASTM D 570	Standard Test Method for Water Absorption of Plastics
ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 2583	Standard Test Method of Indentation Hardness of Rigid Plastics by Means of Barcol Impresser
ANSI/NSF-61	Drinking Water System Components – Health Effects

D. Source Quality Control:
   1. Finish of trough and weir plates and appearance shall meet requirements of AWWA F101.
      a. Provide inspection reports for finish and appearance for fabricated trough and weir laminates.
   2. Furnish affidavit that material was manufactured, sampled, inspected, and conformed to requirements in accordance with AWWA F101.

1.04 SUBMITTALS

A. General Requirements
   1. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Supplier/Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Supplier/Subcontractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Action Submittals
   1. Manufacturer's literature, illustrations, specifications, and engineering data including critical dimensions, weights, jointing and connections, fasteners, and anchors; materials of construction; sizes, spacing and locations of structural members, connections, attachments, openings, fasteners, and loads.

2. Drawings showing the general arrangement of the equipment and methods of installation with detailed mounting information. Indicate provisions for thermal expansion and contraction and the capability to sustain all external and internal loads that may be applied during construction and operation.
3. Calculations confirming compliance with the requirements of this section and AWWA F101 including trough stress, deflection under loadings, and expansion/contraction.
4. Trough manufacturer shall provide concrete anchor bolt sizing and installation details (anchor bolts to be provided and installed by Contractor).

C. Information Submittals:

1. Manufacturer's installation procedures and method of shipping, along with recommendations for short and long-term storage
2. List of recommended spare parts and special tools along with description of each part, quantity recommended, and unit pricing for each part.
3. Samples
   a. Samples: Submit 4-inch by 6-inch sample of the trough material furnished in color specified. Samples shall be taken from plant production and shall be representative of actual construction, workmanship, appearance, and surface hardness.
   b. Copies of laminate glass content test results from representative laminate samples including glass content and tensile/flexural test results.
   c. Inspection reports for finish and appearance for fabricated trough and weir laminates
4. Certifications
   a. Affidavit of compliance stating that material was manufactured, sampled, and inspected, and conformed to requirements in accordance with AWWA F101.
   b. Provide certification that all wetted parts and sealants in contact with the process water are NSF certified for contact with drinking water.
   c. In support of Part 1.03.A.3, provide list of ten similar projects within the last 10 years that the manufacturer has designed and fabricated and in successful service for at least 5 years, including trough size and length, client name, facility name and contact, location, and year installed.

C. Closeout Submittals

1. Completed form 43 05 11-A Manufacturer's certificate of proper installation each filter.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to insure uninterrupted progress of the Work.

B. Handle all materials and appurtenances carefully and in accordance with manufacturer recommendations. Package troughs to avoid damage during handling and shipment. Place fiberboard or plastic corners at edges of fabrications to prevent damage from bands. Items which are damaged will not be acceptable. Protect all bolt threads from damage and corrosion.

1.06 MANUFACTURER'S WARRANTY

A. Warranty: Warranty shall be for a period of 1 year from date of substantial completion unless standard warranty is for a longer term. Provide the longer of 1 year, or standard warranty.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. The Engineer believes the following candidate manufacturers can produce equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include.

1. Leopold (Xylem), Zelienople, PA
2. Fiberglass Fabricators, Inc., Smithfield, RI
3. Warminster Fiberglass, Southamption, PA
4. or approved equal.

2.02 DESIGN

A. General:

1. Construct troughs of fiberglass-reinforced polyester resin laminates and to the dimensions and shapes shown on the drawings. Troughs shall be a minimum of 1' 9" deep and 1' 6" wide.
2. The washwater troughs shall be designed in accordance with the provisions of AWWA F101 and this section, whichever is more stringent. Troughs shall span across the filter basin with intermediate supports as required by the manufacturer to meet the maximum tolerances shown. Each trough shall be closed on one end for connection to the filter wall. It shall be attached by means of a bolted connection and shall be supported in a manner that will resist downward and uplift forces but allow for thermal expansion. The open end will pass through the gullet wall and spill directly into the waste gullet allowing an unobstructed discharge pattern. An integrally molded water stop shall be provided on the discharge end of the trough to create seal with concrete encasement. The completed troughs shall be dimensionally stable and vibration free during operation. Stiffeners, if required, shall be designed to prevent the troughs from vibrating during all stages of operation. Design loads shall be as indicated in AWWA F101 and this section, whichever is more stringent.
3. Prior to fabrication of washwater troughs and support systems, Supplier/ Subcontractor shall provide measurements for installation of troughs and verify dimensions indicated on the Drawings. Manufacturer shall ensure troughs and ancillary appurtenances fit within the available space.
4. Maintain a minimum of 2 inches freeboard below the weir edge in the trough under maximum flow conditions.
5. Filter troughs shall be designed for intermittent exposure to chlorinated water up to 50 parts per million free chlorine for filter cleaning/disinfection.

6. Trough manufacturer shall be responsible to design and provide the entire support system for the troughs including structural support members, connections from troughs to supports, connections from troughs to concrete filter structure, and all other support system accessories and connections required for a complete installation. Troughs shall be designed to meet specified requirements without the need of external bracing. No part of the support system shall contact the filter media. Support systems shall be designed to not trap or hold water when the filter is drained.

B. Service Requirements:
   1. Service: washwater troughs
   2. Capacity per trough during backwash: 1460 gpm
   3. Backwash type: hydraulic, air scour, combined air/water
   4. pH range of liquid: 6 to 8
   5. Water temperature: 1 deg C to 10 deg C
   6. Minimum width: 18-inches
   7. Minimum height: 21-inches
   8. Trough length: 12-feet 0-inches (inside filter box dimension, not including portion through wall)
   9. Number required: 4 per filter, 24 total.

C. Troughs shall be capable of supporting, within stress and deflection limitations, the following loads, and related considerations:
   1. Gravity load shall be all downward loads including the weight of the trough and associated attachments together with the weight of water filling the trough completely.
   2. Uplift load shall be the buoyant load acting vertically upward if the filter cell is filled from below with the trough empty - the load which acts vertically upward and which is equal in magnitude to the weight of the water displaced by the trough, with trough weight neglected. Consider the line of action of this force to pass through the centroid of the submerged cross-sectional area.
   3. Lateral load shall be the load induced by differential water levels on either side of the trough walls. The maximum possible differential exists when the trough is empty, and the tank is full or when the trough is full, and the tank is empty.
   4. Backwashing load shall be the vertical load down during cell backwash and shall include the weight of the trough and any attachments, such as weirs and spreaders (ignoring buoyancy due to 2" lower inside water depth).
   5. Point load of 300 lbs. at any part of the trough.
   6. Design end flanges and blind ends to be a minimum of 1.5 times the nominal thickness of the trough, conforming to the fiber stress limitations as specified, and designed for anchorage loadings.
   7. When calculating deflection, fiber stress and other critical properties, use the maximum possible differential existing when the trough is empty and the tank full, or when the trough is full, and the tank is empty.

D. Design troughs to meet the deflection limits specified below:
   1. Vertical Deflection: Maximum vertical deflection under full buoyant or gravity load measured at the mid-point between supports shall not exceed 3/16-inch or L/1000, whichever is less, where L is the unsupported length in inches.
   2. Side Wall Deflection: Maximum trough sidewall horizontal deflection under full lateral load shall not exceed 3/16-inch or D/100, whichever is less, where D is the trough depth, in inches.
   3. Maximum bottom deflection under full buoyant or gravity load shall not exceed 3/16-inch or W/100, whichever is less, where W is the trough width in inches.

E. Design trough systems to resist torsional oscillations induced by the flow of water over the trough edges. Maximum allowable torsional oscillation sideways or torsionally during normal operating conditions shall be 3/8-inch. Provide torsional stabilization by methods described in Section 3.2.3.3 of AWWA F101 when torsional oscillation exceeds the maximum allowable limit. Provide wall-to-wall lateral stabilizers for backwash troughs installed in air-scour backwash systems as specified in Sections 3.2.3.1 and 3.2.3.2 of AWWA F101, respectively. Design of stabilizers and appurtenant mounting hardware shall be the responsibility of the trough manufacturer.

F. Design troughs to accommodate a thermally induced expansion or contraction in length of at least 1/8" per 20' length of trough over a temperature range of 10 °F to 100 °F without exceeding the deflection or strain limitations herein.

G. Supplemental to the deflection criteria above, the troughs shall also be designed such that the maximum wall stress under the most severe loading conditions is less than or equal to 1500 psi. This stress criterion is equivalent to 7:1 safety factor (approximate) as applied to the tensile and flexural properties of contact molded troughs and launders.

H. The maximum bending stress and shear stress under the most severe load conditions shall not be greater than 11,400 psi and 14,000 psi respectively. The troughs shall be designed to accommodate temperature-induced stresses resulting from differences in thermal expansion between trough and supports.

2.03 DETAILS OF CONSTRUCTION

A. Troughs shall be Type I fabrications as defined in Section 2 of AWWA F101.

B. Materials of Construction
   1. Reinforcing materials:
      a. Glass Fiber: Materials used shall be Type E (electrical borosilicate), or equivalent, glass with a chrome or silane finish, and a binder compatible with the resin. Surfacing veil, if used, shall be 0.010-inch Type C (chemical) or equivalent, veil with a binder containing silane and compatible with the lay-up resin.
      b. Synthetic Fibers: Use synthetic surfacing mat for chemical environment when Type C veil is not compatible with the intended chemical environment.
      c. Metallic: Metal reinforcements shall be free of rust, oil, and foreign matter. Completely encapsulate reinforcement with 1/8-inch laminate to ensure against pinhole bleeding and subsequent rust streaking. Galvanizing or rust inhibitive priming does not preclude requirement for encapsulation.

d. Composites: Use liquid-resistant materials such as end-grain balsa wood or closed-cell polyurethane foam for core materials. Standard wood products are not acceptable.

2. Plastic resin:
   a. Resin shall be a commercial-grade polyester thermosetting resin, which has either been evaluated in a laminate or which has been determined to be acceptable for the service conditions intended.
   b. Resin shall contain no fillers or additives except as follows:
      1) A thixotropic agent, which does not interfere with laminate quality or with the required chemical resistance of the laminate, may be added for viscosity control.
      2) Pigments, dyes, or colorants used shall be suitable for contact with potable water and which have been determined by at least 5 years previous service to be acceptable for the service condition without fading or chalking from original color standard. Pigments shall be light stable, not soluble in water and compatible with the resin. Color shall be translucent blue green.
      3) Ultraviolet Stabilization: Provide ultraviolet stabilizers in all laminates. The laminate shall exhibit not greater than 2 percent deterioration of flexural and tensile properties after 1000 hours of exposure in a Type E, single open-flame, sunshine carbon-arc lamp apparatus as detailed in ASTM G 23.
      4) Additives: Add catalysts, accelerators and/or promoters to provide a complete cure of the laminate and to meet the physical properties specified herein.

C. Laminate Construction
   1. General: Laminate comprising the fabrications shall consist of a molded or inner surface, a structural layer, and an exterior or outer surface with integral metallic structural elements as required.
   2. Inner Surface: The molded or inner surface shall be one of the following systems:
      a. A resin-rich layer, 0.010 to 0.020-inch thick, reinforced with a C veil surfacing mat or an organic fiber surface material in accordance with Paragraph 2.03.B.1. This resin-rich layer shall contain less than 20 percent by weight of the reinforcement material.
      b. A gelcoat consisting of a resin-rich layer 0.015 to 0.020-inch thick may be used in place of that specified above. Acceptable commercial gel-coat resins shall have been tested and proven in fabrications manufactured for use in potable water service. The gelcoat shall be compatible with the resins and shall not show delamination from the substrate when subjected to the tests described in Section 5 of AWWA F101. Gelcoat used for surfacing shall be a commercially manufactured gelcoat, shall be crack and craze resistant, and exhibit the following properties:

Property	Test Method	Value of Property
Minimum Tensile Strength	ASTM D 638	12 x 10^3 psi
Flexural Strength	ASTM D 790	19 x 10^3 psi
Minimum Modulus of Elasticity	ASTM D 638	9 x 10^5 psi
Minimum Barcol Hardness	ASTM D 2583	35
Maximum Water Absorption	ASTM D 570	0.2%

Property	Test Method	Value of Property
Porosity, Blisters, Wrinkles	None	

3. Structural Layer:
   a. Reinforcement placed subsequent to that installed in the inner surface shall consist of plies of chopped strand mat or spray-up passes to provide a laminate structure in accordance with the requirements herein.
   b. In all structural designs, each successive ply or pass of reinforcement shall be thoroughly wetted with resin and shall be well rolled to exclude all air pockets and bubbles prior to the application of additional reinforcement.
4. Exterior Surface: Exterior or outer surface shall consist of a resin-rich layer not less than 0.020-inch thick of resin paraffinated to prevent air inhibition. Apply exterior surface after gelation or cure of the structural layer suitably embeds all reinforcing fibers.

D. Integral Metallic Elements: Encapsulate integral metallic structural elements, where required, in accordance with Paragraph 2.03.B.1.c. Extend overlay laminate or encapsulate, where feasible, a minimum of 2-inches beyond the metal members.

E. Composite Structural Elements: Encapsulate core elements of composite structural fabrications with a minimum of 1/8-inch structural laminate layer. Extend overlay, where feasible, not less than 2-inches beyond the core member.

F. Reinforce troughs with integrally shaped longitudinal stiffener sections. Additional horizontal stiffness and rigidity may be provided using spreaders placed at appropriate points and fastened to the troughs with stainless steel hardware.

G. Laminate Cuts, Slots, and Holes: Sand smooth and seal with resin solution all cut edges, drilled holes, machined slots and similar work and laminate structures. Paraffinate resin solution to prevent air inhibition and to ensure complete sealing of edges to prevent water from penetrating or wicking into the laminate.

H. Tolerances:
1. Top edges of troughs shall be level and parallel with a tolerance of 1/8-inch, measured when the fabrications are empty.
2. Length of troughs shall have a tolerance of 1/8-inch per 10 feet.
3. Thickness of fabrications shall be in accordance with requirements specified in Article 2.02 but not less than 3/16-inch. Thickness tolerance shall be plus 1/8-inch minus zero, and in no event shall thickness be less than 3/16-inch.
4. At locations of supports such as saddles, thickness shall be at least 1.5 times the nominal thickness of the fabrication and shall be in accordance with the fiber stress limitations specified in Paragraph 2.02.G.
5. End flanges and blind ends shall be not less than 1.5 times the nominal thickness of the fabrication and shall be in accordance with the fiber stress limitations specified in Paragraph 2.02.G.

I. Finish and Appearance:

1. Check finished laminate visually. Defects in excess of limitations stipulated in Table 3 of AWWA F101 may be cause for rejection. Defects in excess of those listed in Table 3 of AWWA F101 may be repaired except where such repairs may affect the serviceability of the fabrication.
2. Repair defects by sanding or grinding to remove defective areas. Follow by coating with an overlay of paraffinated resin, used for manufacture, and reinforcement consisting of a minimum of one layer of 1.5 oz/sf chopped strand glass, plus a surfacing mat 0.015-inch of gelcoat. Buildup all repaired areas until the surface is flush and the original thickness is restored. Fill pits or other small deep defects with resin putty. All such remedial work shall be subject to the approval of Engineer.
3. There shall be no areas of the laminate that are excessively resin rich or poorly wetted out. The laminate shall be dense without dry spots or cracked or crazed surfaces. Minimum ratio of resin to glass shall be 70 to 30.

J. Minimum Physical Requirements: All laminates shall meet the minimum physical properties listed below:

Property	Test Method	Value of Property
Tensile Strength	ASTM D 638	12.0 x 10^3 psi
Flexural Strength	ASTM D 790	19 x 10^3 psi
Flexural Modulus	ASTM D 790	9 x 10^5 psi
Barcol Hardness	ASTM D 2583	35 min.
Izod Notched Impact	ASTM D 256	13 ft-lb/in.
Water Absorption (24 hr.)	ASTM D 570	0.2% max.

K. Trough Details

1. Provide an integrally molded water stop on the discharge end of each trough for installation in oversized wall openings.
2. Trough Leveling Adjustment and End Supports:
   a. Provide assembly at the closed end of the trough to allow minimum vertical leveling adjustment of 1-1/2 inches. Provide space between mounting walls and trough for expansion per manufacturer's recommendation. Troughs shall be watertight. Supports shall be 316 stainless steel.
3. Adjustable Weir Plate
   a. Adjustable straight edge weir plates shall be provided for each trough.
   b. The weir plates shall be constructed of fiberglass that meet the fabrication standards established for Type I per AWWA F102.
   c. Size: 1/4-inch x 6-inch x length of trough.
   d. Weir plates shall be installed by manufacturer and field adjusted.
   e. All mounting hardware shall be 316 stainless steel.
4. Spacer Rods
   a. Sufficient plastic spacer rods shall be included to maintain a uniform width over the length of trough.
   b. Spacer rods shall be spaced to prevent buckling and to provide maximum resistance to water loading on the sidewall of the trough.

c. Spacer rods shall be spaced per manufacturers design and no greater than 30-inches on center.

2.04 IDENTIFICATION

A. Provide each trough furnished under this Specification with product identification as described in Section 6.1.1 of AWWA F101.

2.05 ACCESSORIES

A. Provide all mounting brackets, supports, stabilizing bars, angles or rods, fasteners and similar accessories required for installation of the equipment furnished. All accessories shall be Type 316 stainless steel and meet requirements of Division 05.

B. Manufacturer shall size anchor bolts for provision and installation by Contractor.

PART 3 EXECUTION

3.01 INSTALLATION

A. Inspect and verify that structures or surfaces on which the equipment will be installed have no defects, which would adversely affect the installation. Promptly report, in writing, defects which may affect the Work to the Engineer.

B. Type 316 stainless steel trough supports, and hardware shall be installed in accordance with the provisions of Division 05 and the trough manufacturer's written instructions.

C. The troughs shall be installed in full accordance with the manufacturer's instructions by mechanics skilled in the installation of this type of work, under the supervision of the manufacturer's representative.

D. Troughs shall be aligned and leveled, free of warp or twist, with no greater than 1/8-inch variation between any 2 points on the weir edge. Across individual filter/contactor basins, align trough weirs to within plus or minus 1/8 inch of each other.

E. Gasket sealing material between the trough and the wall shall be ¼" neoprene sheet.

F. All joints shall be sealed with 1/8" neoprene gasket material, full width of flange, providing a seal between sections.

G. After the troughs have been leveled and aligned to the required accuracy, the troughs, stabilizer assemblies, and support assemblies shall be field drilled and bolted.

H. Install plastic spacing washers between the closed ends of troughs and the walls of filter boxes.

I. All holes, superficial damage, and other cut surfaces shall be sanded smooth and properly resin sealed according to manufacturer instructions.

3.02 COMMISSIONING, TESTING AND START-UP

A. Commissioning, testing and Startup shall conform to the requirements of Section 01 91 00

B. Filter boxes shall be individually filled with water to check trough elevation tolerances. For any not meeting tolerances, adjust weir plates to maintain level tolerances.

C. During backwashing including at the maximum design rate, observe and inspect troughs for deflection, oscillation, cracks, blisters, surface porosity, chips, delamination, or other defects. Correct any deficiencies found.

END OF SECTION

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