# SALT LAKE CITY CORPORATION

## THE DEPARTMENT OF PUBLIC UTILITIES

PROJECT MANUAL FOR CONSTRUCTION OF

# City Creek Treatment Plant Upgrades Package 2

**PROJECT NO. 512260089**

**FISCAL YEAR 2023**


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SALT LAKE CITY CORPORATION
Salt Lake City, Utah

**PROJECT MANUAL**

FOR

# City Creek Treatment Plant
# Plant Upgrades Package 2

**PROJECT NO. 512260089**

*PREPARED FOR*

DEPARTMENT OF PUBLIC UTILITIES
ENGINEERING DIVISION
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# T A B L E  O F  C O N T E N T S

**City Creek Treatment Plant Upgrades**

**Package 2**

**Project No. 512260089**

END OF DOCUMENT

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# SECTION 01 11 00
# SUMMARY OF WORK

## PART 1 GENERAL

### 1.1 SUMMARY

A. The work covered under this contract will be performed at the site of:

**2200 th City Creek Canyon Road, Salt Lake City UT, 84103**

### 1.2 DESCRIPTION OF OWNER'S PROJECT

A. The project included modifications to convert the existing City Creek Water Treatment Plant from a conventional filtration facility into a direct filtration facility. This includes bypassing the existing flocculation and sedimentation basins, retrofitting two existing filters into flocculation basins and installing a new disinfection sample location.

### 1.3 CONTRACTS

A. Construct the Work under a single unit price contract.
   1. The CONTRACTOR shall provide a professionally prepared, movable temporary project sign as outlined in Section 01 58 00, Project Identification and Signs at the work location of the project.

### 1.4 WORK OF THIS CONTRACT

A. The work to be performed under this contract includes the following modifications to existing facilities; this is a brief summary, and does not represent all tasks:
   1. Demolition and salvage of flocculators and drives in existing flocculation basins.
   2. Demolition of filter media, piping, underdrains, troughs, and associated appurtenances on Filters 1 and 2.
   3. Modification and installation of salaved flocculators into repurposed Filters 1 and 2.
   4. Installation of new flocculation and sedimentation basin bypass pipe
   5. Installation of remote sampling site and associated radio connections.
   6. All associated electrical and instrumentation work required to make a complete and operable system.

B. Except as specifically noted otherwise, Contractor shall 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.

END OF SECTION

# 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 14 00
# WORK RESTRICTIONS

## PART 1 GENERAL

### 1.1 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.

### 1.2 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).

A. 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.

## 1.3 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 from the entrance gate to the CCWTP drying beds shall not be closed at an time for construction activities.

2. November 1, 2023 to March 31, 2023:
    a. Closure of City Creek Canyon Road between the CCWTP drying beds and CCWTP operations building for construction activities shall be less than 1 hour in duration and shall not have a recurrence interval less than 6 hours.
3. March 1, 2023 to May 15, 2023:
    a. The Owner will close the City Creek Canyon Road to public vehicle traffic. Contractor shall maintain a bicycle/pedestrian access zone for City Creek Canyon Road between the CCWTP filter building and operations building as indicated in the Drawings.
    b. Closure of City Creek Canyon Road between the CCWTP drying beds and CCWTP operations building, including the bicycle/pedestrian access zone, for construction activities shall be less than 1 hour in duration and shall not have a recurrence interval less than 6 hours.
    c. Contractor shall maintain a route of vehicular access to the Operations building for plant staff and/or the fire department at all times. Work shall be coordinated and performed such that the roadway between the filter building and the sedimentation basins and along the south side of the sedimentation basins is not blocked at the same time the main canyon roadway between the Filter building and Operations building is blocked.

D. Project Milestones:
    1. Milestone 1: The 24" bypass piping adjacent to the existing flocculation basins shall be installed, tested, and backfilled to grade by December 30, 2023.
    2. Milestone 2: Work in Filters 1 and 2 will be complete, tested and ready for commissioning by January 30, 2024. Remote sampling site will be completely installed and ready to be turned over to the owner by January 30, 2023
    3. Milestone 3: All remaining bypass piping and connections shall be installed and plan operations will be converted to direct filtration by February 15, 2023. The project will be substantially complete.

E. Utilize the following description of work sequence of critical events and shutdown constraints for scheduling and undertaking the Work. The plant shall remain online and unaffected by the Contractor's activities except for the following shutdowns:
    1. Full Plant Shutdown 1 (work associated with Milestone 2):
        a. Shutdown dates: February 5, 2024 to February 8, 2024
        b. Connect the new 30" bypass pipe to the existing 30" sedimentation basin outlet pipe (a.k.a. filter inlet pipe) as identified in the Drawings. Test the bypass pipe connection. Install new 30" and 16" HDPE pipe and valves into the new flocculation basins.
        c. Disinfect the new floc basins and pipelines following the cleaning, disinfection, and sampling procedures identified in Section 01 75 18.
        d. Commission new flocculation basins. Complete all final inspection and punch list items for the new floc basin and receive written approval from the Owner

## 1.4 REQUIREMENTS FOR OPERATION OF PLANT AND MAINTAINING 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.

## 1.5 OPERATIONS AND MAINTENANCE ACCESS

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

B. Provide access on 1-hour advance notice to process control equipment for plant maintenance personnel and associated maintenance equipment.

## 1.6 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.
   2. Services crossed or located nearby by new yard utilities may require relocation and possible shutdowns.
   3. Pipe alignments as indicated on the Drawings.

# PART 2 PRODUCTS

Not Used.

# PART 3 EXECUTION

Not Used.

END OF SECTION

**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.

1. Location awareness:
   a. Emergency exits: _____
   b. Emergency shower and eyewash: _____
   c. Telephones and phone numbers: _____
   d. Shut-off valve: _____
   e. Electrical disconnects: _____
2. 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?
3. SDS (Safety Data Sheets):
   a. Understand the chemicals and substances in the area you are working in by reading the SDS.
4. 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.
5. 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.
6. Safety equipment:
   a. Shepherd's hook.
   b. ARC flash protection.
   c. Fire extinguisher.
   d. Other: _____.
7. 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.
8. 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.
9. 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 | | | | | |

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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

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

### 1.1 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.

### 1.2 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.

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.

B. 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.

   a. Primavera Project Planner (now owned by Oracle) version 8.2 or later

b. or Microsoft Project.

## 1.3 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.

- Baseline

  Format. ProjectCode (project number)_DocumentType_Date_

  Example. 1701_ScheduleBaseline_03162017.XER

- Monthly Update

  Format. ProjectCode (project number)_DocumentType_Date_

  Example. 1701_ScheduleUpdate_03162017.XER

- 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.

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.

The following information should be provided for each activity:

**a.** Activity ID Number

- Use a four-digit number left justified in the activity I.D. field.
- Alphanumeric activity numbers are NOT acceptable.

**b.** Activity Description

- 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

- 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.
- The intent of this requirement is to ensure that the activities are segmented sufficiently to adequately track progress.

**d.** Activity Start and Finish Dates

- Activity start and finish dates will only be accepted if calculated by the software.
- 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
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

- 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)
- Draft Baseline Schedule submittal
- Preparation and submission of shop drawings, submittals, and any required re-submittals (if applicable)
- Mobilization
- Fabrication and delivery of equipment and materials (if applicable)
- Substantial Completion
- 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.

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.

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.

The Baseline Schedule will consider delivery lead times, construction and access constraints and the coordination of construction with OWNER operations.

1. **Safety Requirements**: Schedule performance should never take precedence over safety. Project schedules must allow work to be performed in a safe manner.

   The CONTRACTOR cannot reduce safety or worker protection in order to shorten schedules, recover lost time or accelerate the work.

2. **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.

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.

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:

- Change Orders to the contract affecting the scope of the work to be performed and the associated schedule completion date

## 1.4 PROGRESS SCHEDULE

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.

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.

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.

***A.*** **Progress Updates**: The CONTRACTOR should show on the Progress Schedule updates of the following:

- The actual dates that activities start
- The actual dates that activities finish
- The remaining duration of activities in progress
- The percent complete of all activities on the schedule (0 percent to 100 percent complete)

***B.*** **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:

- Speed review time
- Explain variances from Baseline on critical path activities
- Explain to the OWNER logic changes and potential schedule conflicts related to dependences.
- Concisely summarize the projected cash flow for the project based on the statused schedule.

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.

## 1.5 ADDITIONAL GUIDANCE APPLICABLE TO CONSTRUCTION SCHEDULES ONLY

In addition to the requirements in Sections 1.1 – 1.4 of this Schedule Guidance Document, the CONTRACTOR's schedule will include the following.

A. **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.

## 1.6 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).

   Also submit a .pdf of the bar chart schedule consisting of the following columns:

   - Activity ID
   - Activity Name
   - Duration
   - Start Date
   - Finish Date

- Float
- Cost

2. **Progress Schedule**: Submit the schedule in native file format (see below).
   Also submit a .pdf of the bar chart schedule consisting of the following columns:
   - Activity ID
   - Activity Name
   - Physical Percent Complete
   - Duration
   - Start Date
   - Finish Date
   - Total Float
   - 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.

   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 |
| **6** | Closeout |
| 6.1 | Closeout |

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# SECTION 01 32 23
# SURVEY AND LAYOUT DATA

## PART 1 GENERAL

### 1.1 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. Survey work shall be performed under the supervision of a licensed land surveyor or registered civil engineer. Contractor shall reestablish reference benchmarks and survey control monuments destroyed by his operations at no cost to the Owner. Contractor shall submit Surveyor's name, cerfificate 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

### 1.1 SUMMARY

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

### 1.2 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.

## 1.3 DEFINITITIONS

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:

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

C. Closeout Submittals:

6. 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.
7. Review comments on Closeout Submittals, and perform the subsequent actions based on the REVIEW ACTION requirements specified below.

D. Samples:

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

E. Mock-Ups:

10. Mock-ups are scale representations of items to be constructed as part of the work as required in the Contract Documents.
11. Mock-ups are Action Submittals.

F. Review Actions:

12. 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.

### 1.4 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

### 3.1 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.

## 3.2 TRANSMITTAL PROCEDURE

A. General:

1. Contractor to complete electronic SLCDPU Project Central Submittal Form: Review the Contract Documents to insure completeness. Expand general category listings. Show individual entries on this form for each item. Attach each item properly labeled.

a. As an example, the general category would be “Plumbing Fixtures” which the Contractor is to break down into individual entries such as “Toilet P-1, Lavatory P-2, etc.” Complete the Submittal Register, and submit it to Engineer.

2. Resubmittals: If a submittal is returned for correction, create a new Submittal workflow and reference the original SR ID number in the description and include the submittal register number. Do not amend the data already contained on the Submittal Register.

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 responsibili¬ty 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

C. ACCESS AND USE OF THE OWNER’s SHAREPOINT WEBSITE

1. The CONTRACTOR shall utilize the OWNER’s SharePoint website for all written CONTRACTOR correspondence, submittals, transmittals, pay applications, schedule updates or other communication where feasible. CONTRACTOR shall utilize OWNER-established SharePoint workflows as directed.

2. The CONTRACTOR shall request access to the OWNER's SharePoint website through the Project Manager, by providing the name, employer, e-mail address and phone number of each individual for which access is requested.
3. All SharePoint workflow functions require one (1) individual to be designated as the point of contact to receive workflow e-mail alerts from the system. The CONTRACTOR shall designate one individual as the point of contact for these workflows at the time access is requested. The point of contact can be changed upon the request from the CONTRACTOR at any time during the execution of the project.
4. The OWNER will determine the level of access to the SharePoint website that will be granted to each individual.
5. The OWNER and or OWNER's Representative shall provide SharePoint training to the CONTRACTOR(s).
6. The OWNER shall provide instruction sheets for the electronic workflows executed through the SharePoint site.
7. CONTRACTOR is required to have access to computer hardware and software that is compatible with the OWNER's SharePoint system, capable of running automated process workflows, and supporting electronic signatures. Minimum system requirements include:
    a. Windows 7 or higher.
    b. Microsoft Internet Explorer version 8 or higher (Google Chrome preferred).
    c. Microsoft Office 2010 or higher.
    d. Latest version of Adobe Acrobat (at a minimum Reader, Standard or Professional for editing).
    e. Broadband internet connection.
    f. Open access to https://slcut.sharepoint.com
8. CONTRACTOR shall verify current system requirements at start of contract and may need to adjust requirements during the contract period to accommodate upgrades or changes to the SLCDPU's system.

D. 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".

E. 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.

F. 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.

## 3.3 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.

## 3.4 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

### 1.1 CONTRACTORS CERTIFICATION

1. 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 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

### 1.1 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. This section supplements but does not supersede specific testing requirements found elsewhere in this project manual.

### 1.2 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. Gas flow meters installed in piping systems with diameters greater than 6 inches shall be calibrated in situ using the pitot tube velocity averaging method. 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 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/ASME B40.1 | Gauges Pressure Indicating Dial Type—Elastic Element |
| ASTM E77 | Method for Verification and Calibration of Liquid-in-Glass Thermometers |
| ASHRAE 41.8 | Standard Methods of Measurement of Flow of Gas |
| Dye Dilution Calibration Method | Flow Measurements in Sanitary Sewers By Dye Dilution, Turner Designs Mountain View, California, |
| | Flow Measurement in Sewer Lines by the Dye Dilution Method, Journal of the Water Pollution Control Federation, Vol. 55, Number 5, May, 1983, pg. 531 |
| | 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 |

## 1.3 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

### 2.1 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.

### 2.2 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. Acceptable documentation forms for all systems and items of equipment shall be

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

produced for review by the Construction Manager as a condition precedent to the Contractor's receipt of progress payments in excess of 50 percent of the contract amount. 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.
   3. As a condition precedent to receiving progress payments in excess of 75 percent of the contract amount, or in any event, progress payments due to the Contractor eight weeks in advance of the date the Contractor wishes to begin any testing work (whichever occurs earliest in the project schedule), 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 an additional ten 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.

## 2.3 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.

## 2.4 OPERATIONAL TESTS

A. Once all equipment and systems have been tested individually, the Contractor shall fill all systems with the intended process fluids. After filling operations have been completed, the Contractor shall operate all systems for a continuous period of not less than 5 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.

## 2.5 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

## 3.1 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.

## 3.2 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.

## 3.3 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:
   a. 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.
   b. 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.

c. 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.

## 3.4 **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. The operational testing period shall be 7 days. 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

# SECTION 01 51 00
# TEMPORARY UTILITIES

## PART 1 GENERAL

### 1.1 OFFICE

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

### 1.2 POWER AND WATER

A. The Contractor shall provide power for construction. Contractor 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.

### 1.3 TELEPHONE

A. The Contractor shall provide telephone service at their construction site office. Radio-telephone service is not acceptable as a substitute for telephone service. Contractor shall not rely on cell phone service at their construction site office.

### 1.4 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 57 00
# TEMPORARY CONTROLS

## PART 1 GENERAL

### 1.1 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:

   *C. 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**:

   *D. 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**:

   *E. 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.*

   *F. Some minimum erosion control and storm water protection components have been identified. These do not constitute all necessary components of a comprehensive SWPPP.*

   *1. The CONTRACTOR shall provide all labor, equipment, materials, and services necessary to complete the work.*

      *a) Site Map: Showing boundaries and BMPs that will be implemented.*

      *b) Concrete washout: Describe in detail how concrete washout will be contained and removed from the site.*

c) *Concrete/Road cutting (must be contained): Describe in detail how concrete & road cutting dust and pollutants will be contained.*

d) *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.*

e) *Erosion/sediment controls: Describe in detail the boundary controls to be used e.g. inlet protection, silt fence, fiber rolls, wattle, cut back, etc.*

f) *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.*

g) *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]

2. *The CONTRACTOR shall identify type and placement of BMPs.*
3. *The CONTRACTOR shall be responsible for implementation and maintenance of all BMPs.*
4. *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.*
5. *The CONTRATOR shall be responsible stabilizing and removing all temporary BMPs at the conclusion of the job.*
6. *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.*

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

H. *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:

C. *Remove all dewatering facilities meeting inspector requirements when no longer required.*

6. Add the following paragraph to **Article 3.4 GROUND WATER CONTROL:**

*E. 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

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# SECTION 01 58 13
# TEMPORARY PROJECT SIGNAGE

## PART 1 GENERAL

### 1.1 SECTION INCLUDED

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

### 1.2 SUBMITTALS

A. Sketch of informational signs.

### 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

### 2.1 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

### 3.1 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.

## 3.2 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 allowed on the site of the Work.

## 3.3 MAINTENANCE

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

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

C. Remove graffiti from signs immediately.

## 3.4 REMOVAL

A. Remove signs, framing, supports, and foundations.

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**


SEAL – 8" RADIUS "BLACK"
BACKGROUND WHITE

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

TEXT SIZE / COLOR

BUILDING A BETTER CITY
**ERIN MENDENHALL, MAYOR**
CITY COUNCIL

TEXT SIZE / COLOR

¾" CDX PYLWOOD

| District 1 | District 2 | District 3 |
|---|---|---|
| VICTORIA PETRO | ALEJANDRO PUY | CHRIS WHARTON |
| District 4 | District 5 | District 6 |
| ANALIA VALDEMOROS | DARIN MANO | DAN DUGAN |

TEXT SIZE / COLOR

District 7
AMY FOWLER

**LAURA BRIEFER, DIRECTOR**

44" x 2" BAR

CONSTRUCTION COMPANY NAME — **CONTACT: INSPECTOR NAME**
SALT LAKE CITY CORPORATION
COMPANY ADDRESS — **SALT LAKE CITY INSPECTOR** OWNER REPRESENTATIVE,
COMPANY PHONE NUMBER — **PHONE NO: 801-###-####**
PROJECT MANAGER
**PHONE NO: 801-483-6348**

TEXT SIZE / COLOR

PUBLIC UTILITIES DISPATCH 801-483-6700

END OF SECTION

# SECTION 01 61 45
# AREA EXPOSURE DESIGNATIONS

## PART 1 GENERAL

### 1.1 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.

### 1.2 RELATED SECTIONS:

A. Section 01 11 00 – Environmental Conditions

### 1.3 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<br>Trace Chemicals | 1 - 10 ppm<br>Dilute |
| Head Space | Low Oxygen, Wet | Hydrogen Sulfide<br>Other trace gases | 10 - 1500 ppm<br>Dilute |

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**

| Facility Number | Facility Name | Room Number | Room Name / Delineation | Exposure Type | Notes |
|---|---|---|---|---|---|
| *01* | *Site* | --- | *Outside the perimeter of facilities, above grade* | *Outdoor* | |
| *“* | *Site* | --- | *Outside the perimeter of facilities, below grade* | *Buried* | |
| *“* | *Site* | --- | *Interior of below grade vaults and hand holes* | *Submerged* | *Does not include manholes on buried piping.* |
| *03* | *Operations Building* | --- | *Electrical Room* | *Indoor Dry* | |
| *“* | *Operations Building* | --- | *Other First Floor Areas* | *Indoor Wet* | |
| *30* | *Flocculation Basins* | --- | *Outdoor* | *Outdoor* | |
| *“* | *Flocculation Basins* | --- | *Basin Interior* | *Submerged* | |
| *40* | *Sedimentation Basins* | --- | *Outdoor* | *Outdoor* | |
| *“* | *Sedimentation Basins* | --- | *Basin Interior* | *Submerged* | |
| *50* | *Filter Building* | --- | *Ground Floor* | *Indoor Wet* | |
| *“* | *Filter Building* | --- | *Below Grade* | *Indoor Wet* | |

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

### 1.1 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.

## 1.2 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

## 1.3 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 |
| 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 |
| NFPA-13 | Installation of Sprinkler Systems |
| OSHA | U.S. Dept. of Labor, Occupational Safety and Health Administration |

| Reference | Title |
|---|---|
| SMACNA | Seismic Restraint Manual Guidelines for Mechanical Systems |

## 1.4 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.

## 1.5 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 1.7 of this section.

## 1.6 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.

## 1.7 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 in or attached to a Risk Category IV structure and needed for continued operation.

C. Non-structural components requiring Special Seismic Certification include, but are not limited to, the following:
   1. Variable Frequency Drives

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 are considered "inherently rugged":
      a. Valves
      b. Pumps
   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

### 2.1 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.

## 2.2 DESIGN CRITERIA

A. Design Codes

| Design | Code |
|---|---|
| Buildings/Structures: | International Building Code 2021 and ASCE 7-22 |
| 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 and UOSH |

*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 & ASCE 7 |
| 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 |

5. Wind Loads:

| | |
|---|---|
| Code: | IBC & ASCE 7 |
| 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-strutural 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 & ASCE 7 |
| Risk Category: | IV |
| 0.2 Sec. Mapped Spectral Response, $S_S$: | 1.23 g |
| 1.0 Sec. Mapped Spectral Response, $S_1$: | 0.46 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 |
| 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 |

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

### 3.1 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

### 1.1 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 disinfect application is at the plant inlet Parshall flume.

### 1.2 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).

### 1.3 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.

## 1.4 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.

## 1.5 PROTECTION

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

# PART 2 PRODUCTS

## 2.1 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

## 3.1 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.

## 3.2 SURFACES TO BE DISINFECTED

A. New flocculation basins.
B. New bypass piping.
C. New Morris pipeline tap and sample line.

## 3.3 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 and sedimentation basins is less than 1 parts per million after 24 hours, repeat disinfection process.

## 3.4 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.

## 3.5 BACTERIOLOGICAL TEST

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

END OF SECTION

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# SECTION 01 78 39
# PROJECT RECORD DOCUMENTS

## PART 1 GENERAL

### 1.1 DRAWINGS

A. Record Documents 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, appurtenances, equipment, electrical conduits, outlet boxes and cables;
   2. Additional documents such as schedules, lists, drawings, electrical and instrumentation diagrams included in the specifications;
   3. Contractor layout and installation drawings such as loop drawings, single line diagrams, control schematics/elementary diagrams, control panel drawings, and wiring drawings; and

B. Unless otherwise specified, record drawings shall be full size.

## PART 2 PRODUCTS – NOT USED

## PART 3 EXECUTION

### 3.1 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.

### 3.2 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.

## 3.3 SUBMISSION

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

D. 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 99 90
# REFERENCE FORMS

## PART 1 FORMS

1.1 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 90 00-A | Coating System Inspection 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 |
| 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-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 | | | | |

| | Contractor | | Construction Manager | |
|---|---|---|---|---|
| | Verified | Date | Verified | Date |
| 3) Control panel | | | | |
| 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 | | | | |

| | Contractor | | Construction Manager | |
|---|---|---|---|---|
| | Verified | Date | Verified | Date |
| 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 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
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## 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 | | | |

Coating System Inspection Checklist

| Step | Description | | Name | Signature | Date |
|---|---|---|---|---|---|
| 8 | Completion of First Finish Coat Application and of Detail Treatment at Transitions or Terminations. | GC QC | | | |
| | | CSM QC | | | |
| | | CSA QC | | | |
| 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 _____

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-C. UNIT RESPONSIBILITY CERTIFICATION FORM

**CITY CREEK TREATMENT PLANT UPGRADES PACKAGE 2**

CERTIFICATE OF UNIT RESPONSIBILITY

FOR SPECIFICATION SECTION _____

_____

[SECTION TITLE]

In accordance with Section _____ 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_____ 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

## CITY CREEK TREATMENT PLANT UPGRADES PACKAGE 2

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? | o Yes | o No | If Yes: | Watts | Volts |
| Type of motor winding over-temperature protection, if specified: | | | | | |

Provide information on other motor features specified:

_____

END OF SECTION

[This page was intentionally left blank.]

## 02 EXISTING CONDITIIONS

02 41 00 Demolition

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.

### 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.

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. UDOT ROW
      a. Flowable fill for abandonment within UDOT ROW shall meet the requirements of UDOT Standard Specification 03575. Submittals shall provide product data, test results, and all documentation as required by UDOT Standards to demonstrate compliance.

# 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” 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 and municipal departments 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. 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.

2. UDOT ROW
   a. Removal and disposal of structures and obstructions that interfere with construction within UDOT ROW shall meet the requirements of UDOT Standard Specification Section 02221. Submittals shall provide product data, test results, and all documentation as required by UDOT Standards to demonstrate compliance.

D. 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.

E. 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. No equipment and materials are designated for salvage.
3. 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.
4. 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**

## 03 CONCRETE

03 11 00 Concrete Forming
03 20 00 Concrete Reinforcing
03 30 00 Cast-In-Place Concrete
03 60 00 Grouting

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 033000.
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 ± 1/16 inch
    Tread from level ± 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 "special moment frames" and "special 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.

## 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.

## 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, as indicated in contract documents, 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.

   1. Shear Wall Jamb Columns

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, 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. Unless noted otherwise on the Drawings, splices in circumferential reinforcement in circular walls shall be Class B tension splices and shall be staggered. Adjacent hoop reinforcement splices shall be staggered horizontally by not less than one lap length (center of lap below to center of lap above) or 3 feet, whichever is greater, and shall not coincide in vertical arrays more frequently than every third bar.
3. Splicing of reinforcing elements noted as "tension tie" members on the Drawings shall be avoided whenever possible. If splices cannot be avoided, the splices shall be made with full mechanical or full welded splice capable of developing at least 125 percent of the specified yield strength of the bar. Splices in adjacent bars shall be staggered at least 30 inches.
4. 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.
5. 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.
6. 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 05 50 00 Metal Fabrications
   3. 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 |
| 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 |

| Reference | Title |
|---|---|
| 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, 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, epoxy and chemical grout for crack injection, and bearing pads.
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.

## 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.

## 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-limestone cement shall be ASTM C595, Type IL (MS), interground, low alkali. In addition to showing compliance with all testing requirements of ASTM C595 (Tables 1-3), cement certification shall also include chemical testing results showing $C_3A$ content less than 8% to match existing Type I/II characteristics.
   2. Hydraulic cements meeting only the Physical Requirements of ASTM C1157 are not permitted.
   3. 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 N, natural pozzolan, or 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.

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. Provide concrete mix designs in accordance with the following guidlines:

| 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 | 4500 | 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 |
| E[c] | 2000 | 57 | -- | - | 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".*

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.), electrical conduit encasement (duct banks). |
| C-1 | Typical cast-in-place structural concrete |
| E[c] | Pipe bedding and encasement and concrete fill |

[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 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.

## 2.04 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.

## 2.05 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.

B. Acceptable products include: BASF Corporation “MasterKure CC 250SB”; Dayton Superior “Cure & Seal 25% J22UV”; or approved equal, conforming to ASTM C1315.

C. Compound shall be clear and applied in accordance with the manufacturer’s instructions.

D. 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.

E. 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 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. 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.

d. 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.

## 3.03 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.

## 3.04 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.

## 3.05 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.

## 3.06 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 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.

## 3.07 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.

## 3.08 EXPANSION JOINTS

A. Expansion joints shall be as shown. Do not extend reinforcement or other embedded metal items through expansion joints. Provide waterstops where indicated.

## 3.09 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.

## 3.10 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.

## 3.11 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.

## 3.12 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. Applly float finish to surfaces of channels, tank bottom slabs, exterior below grade horizontal surfaces, incuding 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 fooring, carpet or ceramic tile, unless specified otherwise.

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.

## 3.13 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.

## 3.14 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.

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.

## 3.15 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 100 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 provid 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.

## 3.16 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.

## 3.17 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.

## 3.18 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 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 22 00. Adhesive anchor bolt grouting is specified in Section 05 05 20. Topping concrete over precast elements and clarifier topping concrete is specified in Section 03 30 00.

### 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 22 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 |

| Reference | Title |
|---|---|
| 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 |
| 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:
   1. Hilti, HIT-RE 500v3
   2. Simpson Strong Tie, SET XP
   3. Approved Equal (equivalent product must have ICC approval for use in cracked concrete in areas with high seismic risk).

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:
   1. Hilti, HIT-HY 70
   2. Simpson Strong Tie, SET XP
   3. Approved Equal acceptable per ICC Report or IAPMO Report for resisting earthquake loads.

## 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 NONSHRINK 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**

# 05 METALS

## 05 05 20 Anchor Bolts

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. 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

### 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 318-14, 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. 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.
8. 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. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
3. 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<br>ASTM F594 Heavy Hex Nuts at Adhesive Anchors, Type 316<br>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 |
| 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 |

| Material | Specification |
|---|---|
| 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**

# 26 ELECTRICAL

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 | Standard for Electrical Safety in the Workplace |
| ANSI C2 | 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.

## 1.03 SUBMITTALS

A. Provide submittals in accordance with Section 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 40 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. 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: All | NEMA 1: Mild steel |

D. 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, All | Steel, HDG | Steel, HDG |
| Outdoor Areas, Non-corrosive | Steel HDG | Steel HDG |

HDG = Hot Dip Galvanized Finish

PVC = PVC Coated

E. Seismic:
   1. Design and install electrical equipment, supports, and anchorage in accordance with the seismic design requirements specified in Section 01 73 23.

## 1.05 STORAGE OF MATERIALS AND EQUIPMENT

A. Store materials and equipment as specified in Section 01 66 00-2.05. Seal indoor designatedequipment 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 7 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 annotatecontract 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 particular 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

c. CABLESPEC [“XHHW] [THWN] for indoor lighting and receptacles

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 |
| Intrinsically Safe | Light Blue |

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 PORTABLE CORD

A. Portable cord shall be provided in accordance with CABLESPEC "CORD," unless otherwise specified. Cords shall contain an equipment grounding conductor.

## 2.06 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 terminalsas 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.

## 2.07 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.

## 2.08 CONDUCTOR NUMBERING

A. Conductor Numbers:
   1. Identify conductors with numbers at both ends. Conductor tag numbers are the equipment number followed by a dash followed by the conductor number specified on the control diagram. Example:
      a. Equipment Tag number = 1900 - L1 where:
      b. 1900 = cable number
      c. L1 = conductor number
   2. Conductors in parallel or in series between equipment have the same conductor number. Neutral conductors s 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.

## 2.09 WIRE MARKERS

A. Identify aach 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 1.07 Conductor Numbers. 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.

## 2.10 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 boxlocated 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 otherewise 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.

H. Intrinsically Safe (IS) circuits shall be run in dedicated raceway and may not be combined with any other circuits.

## 3.04 PORTABLE CORD

A. Portable power cords feeding permanent equipment, such as pendant cords feeding motors for pumps, cranes, hoists, and portable items shall have a wire mesh cord grip of flexible stainless steel wire to relieve the tension from the cable termination. Connection of portable cords to permanent wiring shall be accomplished with dedicated boxes and terminals blocks.

## 3.05 TESTING

A. The Contractor shall test conductors, wire, and cable in accordance with Section 26 08 00.

## 3.06 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:

| Type | Volt | Product | Purpose |
|---|---|---|---|
| CAT6 | 300 | 4-PAIR, UNSHIELDED TWISTED PAIR CAT 6 CABLE | NETWORK COMMUNICATION <= 10Gbps |
| SIC | 600 | P-OS: 1-PR#18 or 16SH or 1-TR#18 or 16SH | CABLE TRAY RATED INSTRUMENT CABLE |
| RHW | 600 | RUBBER INSULATED OUTDOOR INDUSTRIAL GRADE SINGLE CONDUCTOR | POWER & CONTROL |
| THWN | 600 | PVC INSULATED WITH NYLON JACKET BUILDING GRADE CONDUCTOR | LIGHTS & RECEPTACLES |
| XHHW | 600 | XLP INSULATED INDUSTRIAL GRADE CONDUCTOR | POWER, CONTROL, LIGHTING, & RECEPTACLES |

## 3.07 CABLE SPECIFICATION SHEETS (CABLESPEC) – CAT6

A. Cable System Identification:
   1. CAT6

B. Description:
   1. IEC Category 6 UTP; TIA/EIA-568-B.2 Category 6
   2. NEC CMR (riser) rated
   3. UL 444 – Standard for Safety Communications Cables compliant
   4. UL1685 flame rating compliant

C. Conductor Material:
   1. Solid Bare copper
   2. 23AWG

D. Insulation:
   1. Material: Polyolefin
   2. Color Coded conductor insulation

E. Jacket:
   1. LSZH PVC - Low Smoke Zero Halogen Polyvinyl Chloride
   2. Sequential Footage Marking: every two feet along jacket
   3. Color: Black

F. Manufacturer(s):
   1. Cooper Industries – Belden 7940T
   2. Commscope: Systimax 5071A
   3. Or equal.

G. Execution:
   1. Applications:
      a. Network communications <= 10Gbps
   2. Installation:
      a. Install in accordance with associated equipment manufacturer's instruction.
   3. Testing:
      a. Test in accordance with paragraph 3.05.

## 3.08 CABLE SPECIFICATION SHEETS (CABLESPEC) – SIC

A. Cable System Identification:
   1. SIC

B. Description:
   1. Single twisted, shielded pair or triad, 18 or 16 AWG, instrumentation and signal cable; UL listed; Cable Tray rated

C. Voltage:
   1. 600 volts

D. Conductor Material: Bare annealed copper; stranded per ASTM B8

E. Insulation:
   1. 15 mil, Polyvinyl Chloride (PVC) with 4 mil nylon, 90 degree C temperature rated; Color Code per ICEA Method-1: Pairs-Black and White with one conductor in each pair printed alpha-numerically for identification

F. Lay:
   1. Twisted on a 2-inch lay

G. Shield:
   1. 100 percent, 1.35 mil aluminum-Mylar tape with a 7-strand tinned copper drain wire

H. Jacket:
   1. 45 mil Polyvinyl Chloride (PVC)

I. Flame Resistance:
   1. UL 1685

J. Manufacturer(s):
   1. Okonite, Okoseal-N Type P-OS (Pair(s) Overall Shield) and Type TOS (Triad(s) Overall Shield); or Cooper Industries-Belden equal; or General Cable equal

K. Execution:
   1. Use:
      a. Analog signal cable and RTD device Triad extension cable.
   2. Installation:
      a. Install in accordance with paragraph 3.03.
   3. Testing:
      a. Test in accordance with paragraph 3.05.

## 3.09 CABLE SPECIFICATION SHEETS (CABLESPEC) – RHW

A. Cable System Identification:
   1. RHW

B. Description:
   1. Single conductor power and control cable; Single Conductor 1/0 AWG - Cable Tray rated. Sizes: 14 AWG through 1000 kcmil as shown

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; Class-B stranded per ASTM B8

E. Insulation:
   1. RHW-2 75 degree C wet; RHH 90 degree C dry; Composite of ethylene propylene rubber (EPR) per ICEA, UL 44 and NEMA WC-7.

F. Jacket:
   1. Chlorosulfonated polyethylene; Trade Name Example: Hypalon

G. Flame Resistance:
   1. IEEE 383 & 1202: 70,000 BTU per hour

H. Manufacturer(s):
   1. Okonite: Okonite-Okolon, series 112-11-XXXX; Cablec: Durasheath EP; or Rome equal; or BICC equal.

I. Execution:
   1. Installation:
      a. Install in accordance with paragraph 3.02.
   2. Testing:
      a. Test in accordance with paragraph 3.05.

## 3.10 CABLE SPECIFICATION SHEETS (CABLESPEC) – THWN

A. Cable System Identification:
   1. THWN

B. Description:
   1. Single conductor lighting and receptacle type; Indoor branch circuit conductor.

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; stranded per ASTM B8

E. Insulation:
   1. THWN/THHN, 90 degree C dry, 75 degree C wet,Polyvinyl Chloride (PVC) per UL 83.

F. Jacket:

1. Nylon

G. Flame Resistance:
   1. UL 83

H. Manufacturer(s):
   1. Okonite, Okoseal-N, series 116-67-XXXX; or equal.

I. Uses Permitted:
   1. Lighting, receptacle and appliance circuits

J. Execution:
   1. Installation:
      a. Install in accordance with paragraph 3.02.
   2. Testing:
      a. Test in accordance with Section 26 05 00-3.02 and Section 26 08 00.

## 3.11 CABLE SPECIFICATION SHEETS (CABLESPEC) – XHHW

A. Cable System Identification:
   1. XHHW

B. Description:
   1. Industrial grade single conductor
   2. Sizes: 14 AWG through 750 kcmil as shown

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; stranded per ASTM B8

E. Insulation:
   1. NEC Type XHHW-2; 90 degree C dry and C wet;
   2. Cross-Linked Polyethylene (XLP) per ANSI/NEMA WC70 ICEA S-95-658 and UL-44;
   3. Color: unique colors for sizes ***14, 12 and 10 AWG.***

F. Jacket:
   1. None

G. Flame Resistance:
   1. Not applicable

H. Manufacturer(s):
   1. Okonite, X-Olene; Cablec, Durasheath XLP; or equal.

I. Uses Permitted:

1. Power, control, lighting and outlet circuits.

J. Execution:
   1. Installation:
      a. Install in accordance with paragraph 3.02.
   2. Testing:
      a. Test in accordance with Section 26 05 00-3.02 and Section 26 08 00.

**END OF SECTION**

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. Lighting & Power panels 2 AWG
   2. Exposed metal cabinets 2 AWG
   3. Electrical equipment 2 AWG
   4. 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**

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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.

## 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. 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 conduitIndividual 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 NAMEPLATES

A. Nameplates are specified in Section 26 05 00

## 2.05 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.

## 2.06 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.

## 2.07 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.

## 2.08 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.

## 2.09 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.

## 2.10 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.

## 2.11 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 (WWTP)<br>Exposed (other) | PGRS<br>GRS |
| Nonhazardous | Final connection to equipment and light fixtures | LFS |

## 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:
         1) exposed
      b. Conduits for process equipment:
         1) exposed
      c. Conduit inside structures:
         1) exposed
      d. 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. Installation at structural joints:

1) Rigid metal conduit: Provide O-Z Gedney "Type DX" or Crouse-Hinds "Type XD" bonded, expansion and deflection fitting where conduit across structural joints that crosses structural movement.

2) PVC-coated Rigid metal conduit: Provide Cal-Bond "Type XD" or O-Cal "Type XD" bonded, expansion and deflection fitting where conduit across structural joints that crosses structural movement.

3) Rigid PVC conduit: Provide Carlon "Type XD" non-metallic expansion/deflection coupling where conduit crosses structural joints that allow for 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 in accordance with Specification 31 23 00, Excavation and Fill. Allow for a minimum of two days to cure prior to backfilling.

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 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.

E. 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.

## 3.03 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 wiil comply with raceway lables assigned on the drawings. Where raceway numbers have not been assigned, assigne raceway numbers in accordance with the following system:

| Raceway Prefix | Type of Function |
|---|---|
| C | Control or power - 120V or less |
| H | Power above 600V |
| N | Pneumatic tubing |
| P | Power 208V to 600V |
| S | Signal - data communication or instrumentation |
| X | Spare |

2. Provide 4-digit 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. P = conduit contains power
   b. 3109 = unique 4-digit number
   c. A = letter to distinguish raceways to same equipment

C.

## 3.04 RACEWAY SCHEDULE

A. General:
   1. Raceway shall be as specified on the drawings.

B. Scheduled Raceway:
   1. The size and type of raceway shall be as specified on the drawings.

C. RACESPEC Sheets
   1. The following RACESPECS are included in this section:

| GRS | Galvanized Rigid Steel Conduit |
|---|---|
| LFS | **Liquidtight Flexible Steel Conduit** |
| PGRS | Rigid Steel Conduit, Corrosion-Resistant, Polyvinyl Chloride (PVC) Coated |
| PVC8 | Rigid Nonmetallic Conduit |

## 3.05 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.

## 3.06 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.

## 3.07 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 C80.1, NEMA RN 1, and UL 6.

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.

## 3.08 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 Sizesize:
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.

**END OF SECTION**

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 DESCRIPTION

A. This section specifies the acceptance testing of electrical materials, power distribution and utilization equipment and circuits. Contractor shall provide all labor, tools, material, power, and other services necessary to provide the specified tests.

### 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 |
|---|---|
| NETA ATS | Acceptance Testing Specifications for Electric Power Distribution Systems |
| NFPA-70 | National Electrical Code (NEC) |

### 1.03 SUBMITTALS

A. Functional testing and checkout procedures and schedule shall be provided in accordance with Section 01 33 00.

## PART 2 PRODUCTS

### 2.01 TEST EQUIPMENT AND MATERIALS

A. Test instruments shall be calibrated to references traceable to the National Institute of Standards and Technology and shall have a current sticker showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required.

| Form No. | Title |
|---|---|
| 26 05 00-A | Wire and Cable Resistance Test Data Form |
| 26 05 00-B | Installed Motor Test Data Form |
| 40 61 13-A | Loop Wiring and Insulation Resistance 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 |

## 2.02 PRODUCT DATA

A. In accordance with Section 01 33 00, the Contractor shall submit the completed test report Section 26 05 00-Forms A and B as specified in Part 3 herein.

## PART 3 EXECUTION

## 3.01 TESTING

A. General:
   1. The following specified tests, including correction of defects where found and the subsequent re-testing, shall be completed prior to energization of the equipment or systems. Submit all completed test report forms in a 3-ring binder type notebook at the project Substantial Completion date.
   2. A megohmmeter shall be used for insulation resistance measurements.

B. INSULATION RESISTANCE MEASUREMENTS:
   1. General:
      a. Insulation resistance measurements shall be made on conductors and electrical equipment that will carry current. 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. The ambient temperature at which insulation resistance is measured shall be recorded on the test form.
   2. Conductor and Cable Tests:
      a. The phase-to-ground insulation resistance shall be measured for all 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 in a format similar to Form 26 05 00-A contained in Section 01 99 90, and submitted for acceptance. Insulation with resistance of less than 10 megohms is not acceptable.
   3. 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 for acceptance. All motors shall have their insulation resistance measured before they are connected.

4. 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.
5. Verify that motors are connected to rotate in the correct direction. 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.
6. Power Distribution Equipment:
    a. Transformers, panelboards, and other power distribution equipment shall have their insulation resistance measured phase-to-phase and phase-to-ground.
7. Power Utilization Equipment:
    a. Test receptacles and power outlets using a device to verify polarity, grounding, and the correct wiring connections.

C. 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.
3. 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.

**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 |
|---|---|---|---|---|---|---|---|
| 50-FLC-326 | 50-VFD-326 | 5 | | EXISTING FLOCULATOR 3HP | VT 6P | NEMA-3R Gasketed, Wall Mount | 20 |
| 50-FLC-327 | 50-VFD-327 | 5 | | EXISTING FLOCULATOR 3HP | VT 6P | NEMA-3R Gasketed, Wall Mount | 20 |
| 50-FLC-328 | 50-VFD-328 | 5 | | EXISTING FLOCULATOR 3HP | VT 6P | NEMA-3R Gasketed, Wall Mount | 20 |
| 50-FLC-329 | 50-VFD-329 | 5 | | EXISTING FLOCULATOR 3HP | VT 6P | NEMA-3R Gasketed, Wall Mount | 20 |

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. A load reactor for dV/dT mitigation or motor terminator units for addressing dv/dt effects at the motor
      c. Rectifier, direct current bus filter, and inverter.
      d. Control circuitry interface with Operator Interface Unit
      e. 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 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. Environmental Conditions:
a. Ambient temperature:
1) 0 to + 40 degrees C / [104 degrees F
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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 42,000 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 chang
        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

## 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 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] [in 1.01.C].

## 2.07 SPARE PARTS

A. The following spare parts shall be supplied with each type or frame size AFD:
    1. Three sets of all replaceable fuses.

## 2.08 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.

**END OF SECTION**

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# 31 EARTHWORK

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.

## 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.

### 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 compacting 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 street rights of way.

### 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 33 05 25.
   2. Qualification information of excavation support system designer (Professional Engineer registered in the State of Utah) in accordance with Section 33 05 25.

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 refill for foundation stabilization, and water. Include laboratory moisture-density relations of soils.

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.

## 1.05 SITE CONDITIONS

A. Plan for and provide work zone traffic control where required to meet UDOT and governing local 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: 12 inches.
      d. Color: Blue (for water) and Orange for Cathodic Protection test wires.
      e. Lettering: Minimum 1-inch high, permanent black lettering imprint continuously over entire length.
         1) Text shall be: “High Pressure Waterline Buried Below” for water and “WBWCD CP Test Wires” for cathodic protection wire.
         2) Provide over other utilities exposed if utility owner requires.
         3) Provide over WBWCD cathodic protection wires.
      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, 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 33 05 25, Excavation Support Systems.
        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): 95 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 4 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 Contractor 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 12 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 compaction fails to meet the specified 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 D2419 | Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate |
| 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 or 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 coordinated with the approval of the Engineer.

# PART 2 PRODUCTS

## 2.01 FILL MATERIALS

A. Type A:
    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:
    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 have a sand equivalent value determined in accordance with ASTM D2419 of not less than 20 and 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:

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:

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. 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:

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:

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 |
|---|---|
| 2 inch | 100 |
| No. 50 | 0-100 |
| No. 100 | 0-8 |
| No. 200 | 0-4 |

H. Type H:

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:

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:

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 per ASTM C 33. 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. The Contractor shall keep excavations reasonably free from water during construction. The static water level shall be drawn down a minimum of 1 foot below the bottom of excavations to maintain the undisturbed state of natural soils and allow the placement of any fill to the specified density. Disposal of water shall not damage property or create a public nuisance. The Contractor shall have on hand pumping equipment and machinery in good working condition for emergencies and shall have workmen available for its operation. Dewatering systems shall operate continuously until backfill has been completed to 1 foot above the normal static groundwater level.
2. Groundwater shall be controlled to prevent softening of the bottom of excavations, or formation of "quick" conditions. Dewatering systems shall not remove natural soils. The Contractor shall control surface runoff to prevent entry or collection of water in excavations.

3. Release of groundwater to its static level shall be controlled to prevent disturbance of the natural foundation soils or compacted fill and to prevent flotation or movement of structures or pipelines.

## 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 overexcavated space under footings may be filled with concrete. 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 embankments required by the work, the quantity of material needed to complete the embankments 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, and subbase and pavement thickness shall be made so that the specified thickness of topsoil 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. If the soil is to be cultivated or straw is to be incorporated into the surface, rocks larger than 2-1/2 inches in maximum dimension, roots and other debris on the surface of the slope shall be removed and disposed of prior to cultivation or placement of top soil.
5. Protection of Finish Grade:
    a. During construction, shape and drain embankment and 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. Embankments and Fills:
1. Construct embankments and fills at locations and to grade indicated.
2. Compact by sheepsfoot, pneumatic rollers, vibrators, or by other equipment as required to obtain specified density.
3. Control moisture for each layer necessary to meet requirements of compaction.

H. 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.

## 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 |

**Table A, Fill Classifications**

| Fill class | Material type | Maximum uncompressed layer depth, inches | Minimum relative compaction, percent | General application |
|---|---|---|---|---|
| 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[a] | E | 8 | - | Trench Foundation, Fill under slabs for structures and tank slabs with pressure relief valves |
| F1[b] | 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[c] | H | - | - | Embankment slope face, channel slope face |
| I1[c] | I | - | - | Embankment slope face, channel slope face |
| J1[d] | J | 8 | 90 | Excess fill |
| K1 | K | - | - | Substitute fill for unsuitable soils or areas where there is less than 12" of clearance between utilities. |

*a. Compaction of layers shall be accomplished in two passes of equipment with complete coverage across the width of the field.*

*b. Material shall not be used for bedding or initial backfill for plastic pipe.*

*c. Fill material shall be grouted as specified in paragraph 3.08.*

*d. Asphalt and concrete slabs from demolition may be placed at the bottom of the fill side by side to form a continuous pad. Clearing and grubbing is not required unless shrubs are taller than 3 feet. Mucking of the subgrade and keying or benching of adjoining embankments is not required.*

## 3.05 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 foundation. No concrete or masonry shall be placed until the foundation 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. 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
   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 EARTHWORK FOR EMBANKMENTS

A. Foundation Preparation:
   1. The surface of the foundation shall not contain standing water and shall be free of loose material, foreign objects and rocks greater than 6 inches in maximum dimension. Immediately prior to placement of embankment fill material, the foundation surface shall be thoroughly moistened, scarified to a depth of 6 inches, moisture conditioned again as necessary and recompacted to 95 percent relative compaction. After the preparation has been completed, the Contractor shall promptly place and compact the first lift of embankment on the foundation to prevent damage to the surface. If the foundation surface is damaged, the Contractor shall repair the surface to the specified condition. In any areas where materials become soft or yielding, such materials shall be removed, disposed of, and replaced with specified material. The surface of the embankment shall be maintained to permit travel of

construction equipment. Ruts in the surface of any layer shall be filled and leveled before compacting.

B. Embankment Fill:
   1. Rocks, broken concrete, or other solid materials, which are larger than 4 inches in greatest dimension, shall not be placed in embankment areas where piles are to be placed or driven.
   2. Fill material having a sand equivalent value less than 10 shall be placed in the lower portions of embankments and shall not be placed within 2.5 feet of finished grade.
   3. When the embankment material consists of large, rocky material, or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, such material shall be well distributed throughout the embankment. Sufficient earth or other fine material shall be placed around the larger material as it is deposited so as to fill the interstices and produce a dense, compact embankment.
   4. Unless otherwise specified, the embankment shall be raised to form an approximately horizontal plane extending transversely to the final slopes. The embankment shall be crowned at all times during construction so that water will drain readily off the embankment.
   5. The temporary differential elevation between any two adjoining zones of the embankment due to construction operations shall not exceed 24 inches.
   6. If the compacted surface of any layer of material is too smooth to bond properly with the succeeding layer, the surface shall be scarified. If required, the surface shall be sprinkled or otherwise moisture conditioned before the succeeding lift is placed. Any surface crust formed on a layer of fill material that has been dumped and spread shall be broken up by harrowing and, if required, the full depth of the affected layer shall be moisture conditioned immediately prior to rolling.

C. Key Construction:
   1. Where specified, a key shall be excavated along the length of the toe of fill slopes. The exposed soils along the key and under fill areas shall be disced and/or scarified to a depth of at least 12 inches, moisture conditioned to within 3 percent of optimum moisture content, and compacted to at least 90 percent of maximum dry density.

D. Embankment Tolerances:
   1. General: Embankment slopes within 4 feet of shoulder grade shall vary less than 0.5 foot from the designated slope. Slopes beyond 4 feet from shoulder grade shall vary less than 1 foot from the designated slope. Measurements for variance shall be made perpendicular to the slope. Slopes which are 6 to 1 or flatter shall vary less than 0.2 foot from the designated slope.
      a. If embankments are constructed of rock greater than 12 inches in diameter, the slopes more than 4 feet below shoulder grade may vary up to 2 feet from the designated slope.
   2. Roadway Embankment Tolerances: The excavated surface shall be less than 0.08 foot above or below the grades specified after deducting for the roadway pavement thickness.
      a. Vertical alignment tolerances permitted on the roadway surface shall not exceed plus or minus 0.30 feet from the vertical alignment specified, with the provision that within the tolerance range local surface irregularities shall not exceed 0.15 feet as measured by the gap between the roadway surface and a 10-foot

straightedge placed on any flat graded surface. On vertical curves, the same standards will apply except that an additional gap allowance will be made for the road surface curvature over the 10-foot length of the straightedge.

b. Horizontal alignment tolerances permitted shall not exceed plus or minus 1 foot providing the departure is relatively uniform over any specific length of the roadway.

c. Roadway median strips shall be graded to drain and shall not vary more than 0.1 foot from the specified grade.

## 3.08 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

## 3.09 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.

B. Contractor shall use Class F1 unless specified in the drawings.

## 3.10 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.

## 3.11 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.

## 3.12 COLD WEATHER LIMITATIONS IN PLACING FILL AND BACKFILL

A. 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.

B. 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.

C. 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.

D. Do not place fill materials which contain frozen moisture (snow, ice, sleet, etc.) except as allowed in the paragraphs above.

E. Work performed outside the required temperature limitations is subject to rejection, removal and replacement.

## 3.13 STOCKPILE LIMITATIONS AND DISPOSAL OF EXCAVATED MATERIAL

A. Protect installed pipelines after installation from differential settlement of ground by doing the following:
   1. After backfilling pipelines, do not ever (temporarily or permanently) allow more than 2.5-feet of stockpile or fill depth to be placed (above existing grades shown in drawings) in any part of the permanent easement or within 15-feet (horizontally) from centerline of pipe.
   2. After backfilling pipelines, do not allow stockpiles of earth materials, fills (or other materials of similar density and size) to be deeper (or higher) than a 6:1 (6 horizontal to 1 vertical) upward sloping plane originating at existing ground atop pipe centerline and extending upward and outward from pipe in each direction. For instance, at 18-feet away from pipe centerline, neither temporary, nor permanent, fill depth shall exceed 3 feet (above existing grade) except where the contract document specifically require fills.
   3. If temporary fill is placed in the easement, manholes shall not be buried and shall remain accessible at all times. Temporary fills shall be graded to direct drainage away from manholes.

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 area.

**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**

## 32 EXTERIOR IMPROVEMENTS

32 31 13 Chain Link Fences and Gates
32 12 16 Asphalt Paving

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.

### 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) |
| ASTM A392 | Zinc-Coated Steel Chain-Link Fence Fabric |

## PART 2 PRODUCTS

## 2.01 MATERIALS

A. Chain Link Fabric:
   1. Chain link fabric shall be 2-inch mesh 9-gage wire, hot-dip galvanized after fabrication. Fabric shall conform with the requirements of ASTM A392 and shall have a Class 2 zinc coating.

B. Top and Bottom Tension Wire:
   1. Top and bottom tension wires shall be at least 7-gage galvanized coil spring steel.

C. Barbed Wire:
   1. Barbed wire shall be double strand 12 1/2-gage galvanized steel with 14-gage barbs in 4-point pattern on 5-inch centers and shall have a Class 1 galvanized coating per ASTM A121.

D. Posts, Top Rail, Braces and Gate Frames:
   1. Pipe used shall be ASTM A53, Schedule 40 steel pipe. Posts, rails, braces and frames shall be hot-dip galvanized per ASTM A53, A123 or A153, whichever is applicable. Galvanizing shall apply at least 2.0 ounces of zinc per square foot of surface.
   2. Line posts shall be either "H" columns weighing not less than 2.7 pounds per foot or 2-3/8-inch outside diameter pipe weighing 3.65 pounds per foot. Corner and end posts shall be minimum 2-7/8-inch outside diameter pipe weighing a minimum of 5.79 pounds per foot. Braces and top rails where specified, shall be 1 5/8-inch outside diameter pipe weighing 2.27 pounds per foot. Gate frames shall be made of minimum 2-inch outside diameter pipe. Gate posts shall be 6-5/8-inch outside diameter weighing 19.0 pounds per foot.

E. 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.

F. Concrete:
   1. Concrete for post foundations shall be as specified Section 03 30 00.

## 2.02 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.
   4.

## PART 3 EXECUTION

### 3.01 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.

### 3.02 GATES

A. 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.

**END OF SECTION**

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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. |

| | |
|---|---|
| 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 buttjoints, 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 ofasphalt 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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# 33 UTILITIES

33 05 25 Excavation Support Systems

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**

## 40 PROCESS INTEGRATION

40 05 01 Piping Systems
40 05 06.16 Piping Connections
40 05 07 Hangers and Supports for Process Piping
40 05 19 Ductile Iron Pipe
40 05 24 Steel Process Pipe
40 05 33.13 High Density Polyethylene Pipe Solid Wall
40 05 45 Piping System Identification
40 05 57.23 Electric Motor Actuators
40 05 64.05 AWWA C504, Class 150B.
40 61 13 Process Control System General Provisions.
40 61 21 Process Control System Testing.
40 61 93 PCS IO List
40 61 93.50 Process Control System IO List
40 61 96 Process Control Descriptions

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 (see drawings) and other referenced sections. Except where referenced specification sections specify alternate provisions, the requirements of this Section apply to all piping systems listed in the pipe schedule in the drawings.

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 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   4. Section 03 30 00 – Cast-in-Place Concrete
   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 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 |
|---|---|
| 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 the drawings.
   3. 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 section40 05 07.
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 and40 05 07, 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 Schedule in the drawings), 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 the drawings 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 Section 40 05 07. 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. 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 (Pipe Schedule in the drawings)) | (NA) | All piping |
| Contractor layout drawings (Section 40 05 01) | All piping | (NA) |
| Support design (Section 40 05 07 and related sections) | All piping | (NA) |
| 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. 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 in the drawings 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, , pipe anchors, 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 the drawings and Section 40 05 06.16.

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 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.

## 3.07 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.

## 3.08 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 Schedule in the drawings.

H. Coat gasket with gasket manufacturer's recommended lubricant between flange faces.

## 3.09 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.

## 3.10 INSTALLATION OF BURIED PIPE AND PIPE BELOW STRUCTURES

A. Trenching and backfill for buried pipe: conform to Section 31 23 33.

B. 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.

C. 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.

D. Install pipe in straight alignment. Do not exceed 3/8-inch variance over 30 ft from the true alignment in any direction.

E. Slope gravity lines uniformly from point of origin to discharge.

F. Ensure the pipe alignment stays true during and after placement of concrete encasement.

G. Ensure that the method used to prevent pipe uplift during placement of concrete encasement results in an invert and crown true to intended grade.

H. Maintain circular cross section of pipe.

I. 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.

J. Provide Heat-Shrinkable Cross-Linked Polyolefin Coating or Tape Wrap coating on all flanged, grooved, and welded joints that are buried or below structures.

K. 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

L. Use anti-seize compound with all stainless steel nuts and bolts.

M. Provide detectable warning tape for all buried pipe. Provide tracer (locate) wire as specified in Section 40 05 45.

## 3.11 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.

## 3.12 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.

## 3.13 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.

## 3.14 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.

## 3.15 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.

## 3.16 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.

## 3.17 FIELD QUALITY CONTROL

A. Inspections:
   1. Inspect and provide reports as specified in Section 40 05 07.
   2. Submit the Design Professional's final report before beneficial occupancy by the Owner.

## 3.18 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.

## 3.19 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 Schedule in the drawings.

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.

## 3.20 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.

## 3.21 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.

## 3.22 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.

## 3.23 DISINFECTION

A. Flush and disinfect lines intended for potable water service after testing in accordance with AWWA C651.

**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 BI.1 | Unified Inch Screw Threads (UN and UNR Thread Form) |
| ANSI BI.20.1 | Pipe Threads, General Purpose (Inch) |
| ANSI B16.1 | Cast Iron Pipe Flanges and Flanged Fittings |
| ASME B16.42 | Ductile 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 A153 | Zinc Coating (Hot Dip) on Iron and Steel Hardware |
| ASTM B98 | Copper-Silicon Alloy Rod, Bar and Shapes |
| ASTM F37 | Standard Test Methods for Sealability 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 |

| Reference | Title |
|---|---|
| AWWA C207 | Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in. |
| 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.

B. PRODUCT DATA
   1. 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 2 PRODUCTS

## 2.01 FLANGES

A. General: Flanges shall be flat flanges as specified in the following paragraphs.

B. 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 given in the Piping Schedule exceeds 175 psi. Plain faced flanges shall not be bolted to raised face flanges.

C. Flanges shall be galvanized per ASTM A153 when connected to galvanized steel pipe.

## 2.02 FLANGE BOLTS AND NUTS

A. General:
   1. Provide a washer for each nut. Washer shall be of the same material as the nut.
   2. Nuts shall be Heavy hex-head.
   3. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.

B. Lubricant for stainless steel bolts and nuts:

1. Chloride-free.
2. One of the following or equal:
    a. Huskey FG-1800 Anti-Seize.
    b. Weicon Anti-Seize High-Tech.

C. For ductile iron pipe:
    1. On exposed pipes with pressures equal to or less than 150 psig:
        a. Bolts: ASTM A307, Grade B.
        b. Nuts: ASTM A563, Grade A.
        c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    2. On exposed pipes with pressures greater than 150 psig:
        a. Bolts: ASTM A193, Grade B.
        b. Nuts: ASTM A194, Grade 2H.
        c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
    3. On underwater pipes and pipes adjacent to wet walls:
        a. Bolts: ASTM A193, Grade B8M.
        b. Nuts: ASTM A194, Grade 8M.
    4. On buried pipes:
        a. Bolts: ASTM A193, Grade B7.
        b. Nuts: ASTM A194, Grade 2H.
        c. Coat nuts and bolts with blue Xylan 1424 fluoropolymer. All bolt and nut surfaces are to be chemically cleaned, abrasively blasted, and primed with nickel phosphate primer. The coating shall consist of a minimum of two coats of liquid Xylan 1424 fluoropolymer coating heat cured per the manufacturer's recommendations. Coating shall be applied only by a Whitford Qualified Applicator. A certificate of compliance shall be included with the nut and bolt submittal.

D. Plastic pipe:
    1. On exposed pipes:
        a. Bolts: ASTM A307, Grade B.
        b. Nuts: ASTM A563, Grade A.
        c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    2. On underwater pipes and pipes adjacent to wet walls:
        a. Bolts: ASTM A193, Grade B8M.
        b. Nuts: ASTM A194, Grade 8M.

E. Steel pipe:
    1. On exposed pipes:
        a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
            1) Bolts: ASTM A307, Grade B.
            2) Nuts: ASTM A563, Grade A.
            3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.

b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
   1) Bolts: ASTM A193, Grade B7.
   2) Nuts: ASTM A194, Grade 2H.
2. On underwater pipes and pipes adjacent to wet walls:
   a. Bolts: ASTM A193, Grade B8M.
   b. Nuts: ASTM A194, Grade 8M.

F. Stainless Steel pipe:
1. All applications:
   a. Bolts: ASTM A193, Grade B8M.
   b. Nuts: ASTM A194, Grade 8M.

## 2.03 FLANGE GASKETS

A. General:
1. 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.
2. Gaskets shall be suitable for the specific fluid, pressure, and temperature conditions specified in this Section. The following exceptions apply:
   a. The gasket pressure ratings specified in this Section are minimum pressure ratings. Gaskets shall be suitable for the test pressures given in the Piping Schedule. If the test pressure given in the Pipe Schedule is higher than the gasket pressure rating given in this Section than the test pressure given in the Pipe Schedule governs.
3. For flat faced flanges, use full-face gaskets. For raised-face flanges, use ring type gaskets. Conform to ANSI B16.21.

B. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
2. Material: 0.125-inch thick Viton rubber.
3. Manufacturers: One of the following or equal:
   a. Garlock.
   b. John Crane, similar product.

C. Gaskets for flanged joints in ductile iron or steel water piping (non NSF 61):
1. Suitable for hot or cold water, pressures equal and less than 200 pounds per square inch gauge, and temperatures equal and less than 160 degrees Fahrenheit.
2. Material:
   a. Neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
   b. Teflon ring; or Teflon envelope with non-asbestos filler.

3. Manufacturers: One of the following or equal:
    a. Garlock, Bluegard 3300.
    b. John Crane, similar product.

D. Gaskets for flanged joints in ductile iron or steel drinking water piping meeting NSF 61 requirements:
    1. Suitable for hot or cold water, pressures equal to or less than 200 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
    2. Material:
        a. PTFE material with glass microsphere filler.
    3. Manufacturers: One of the following or equal:
        a. Garlock, GYLON Style 3505.
        b. John Crane, similar product.

E. Gaskets for flanged joints in stainless steel ozone solution water piping meeting:
    1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 400 degrees Fahrenheit.
    2. Material:
        a. Viton A.
    3. Manufacturers: One of the following or equal:
        a. Garlock, GYLON Style 9518.
        b. John Crane, similar product.

## 2.04 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. Reducing Sleeve Couplings:
        a. Rockwell Type 415.
        b. Dresser Style 62.
        c. Romac RC501
        d. Approved equal.
    3. Sleeve-type Flanged Coupling Adapters:
        a. Romac FCA 501.
        b. Rockwell Type 913.
        c. Dresser Style 128.
        d. Approved equal.
    4. 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.

5. Gaskets shall be of similar materias as specified in paragraph 2.04 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 of similar materias as specified in paragraph 2.04 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 for grooved end ductile iron and steel piping:
    a. Suitable for pressures equal to the encapsulating coupling or flange adapter.
    b. Material: Pressure responsive elastomer:
        1) Ductile iron piping: FlushSeal® type:
            a) Halogenated Butyl: Grade M; for temperatures to 200 degrees Fahrenheit.
            b) Nitrile: Grade S; for temperatures to 180 degrees Fahrenheit.
        2) Steel piping:
            a) EPDM: Grade E; for temperatures to 230 degrees Fahrenheit.
            b) EPDM-HP: Grade EHP, for temperatures to 250 degrees Fahrenheit.
            c) Nitrile: Grade T, for temperatures to 180 degrees Fahrenheit.
    c. Gaskets shall be verified as suitable for the intended service:

1) Temperature ratings may vary depending on the fluid/media.

d. Manufacturers: Gaskets shall be of the same manufacturer as the encapsulating couplings/flange adapters:

1) Victaulic Company.

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 2.04. 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.

## 2.05 THREADS

A. Pipe thread dimensions and size limits shall conform to ANSI Bl.20.1.

## 2.06 UNIONS

A. 2-inch and Smaller: Ground joint screwed pattern unions.

B. 2 1/2-inch and Larger: Ground joint flange unions.

C. Dielectric Unions: Match the pipe material except bronze may be used with copper piping. Dielectric unions shall be EPCO, Capitol Manufacturing, or approved equal.

## 2.07 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Flange Insulating Kits: 2-1/2 inches and larger:
   1. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   2. In accordance with applicable piping material specified in Piping System Schedule in the drawings. Provide insulating flange assemblies per ASME B31.9 or B31.1. Flange assembly pressure/temperature rating equal to or greater than pipeline rating.
   3. Galvanically compatible with piping.
   4. Gaskets: Full-face, Type E, with elastomeric sealing element. Sealing element retained in a groove within retainer portion of gasket.
   5. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA G-10 grade).
   6. Insulating Washers: Fiberglass reinforced epoxy (NEMA G-10 grade).
   7. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
   8. Manufacturers:
      a. Pipeline Seal and Insulator, Houston, TX

b. Advance Products and Systems, Lafayette, LA
c. Approved equal

B. Insulating Sleeve Couplings:
1. Rockwell Type 416.
2. Dresser Style 39.
3. Approved equal.

C. Flexible Insulated Couplings:
1. Dresser; STAB-39.
2. Baker Coupling Company, Inc.; Series 216.
3. Approved equal

D. Insulating Unions: Union Type, 2 inches and Smaller:
1. Screwed or solder-joint.
2. O-ring sealed with molded and bonded insulation to body.
3. O-ring sealed with molded and bonded insulating bushing to union body, as manufactured by Central Plastics Co., Shawnee, OK.
4. Approved equal

## 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 for piping systems 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. Piping passing from concrete to earth shall be be flexibly connected per the Standard Details indicated in the Drawings.

## 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 2.06 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 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.

C. Scope Of Work By Design Engineer: Design Engineer has not undertaken design details for supports and anchors for: 16- and 30-inch bypass pipe and 18-inch overflow 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 61 45 – Area Exposure Designations
   3. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   4. Section 03 30 00 – Cast-in-Place Concrete
   5. Section 05 05 20 – Anchor Bolts
   6. Section 40 05 01 – Piping Systems
   7. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping

8. 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 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-58-93 | Pipe Hangers and Supports - Materials, Design and Manufacture |

## 1.04 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.

## 1.05 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.

## 1.06 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.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: 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. 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. 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.

B. Additional requirements: 40 05 01.

## 1.08 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 58, 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. 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.

h. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.

i. 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.

j. 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.

k. 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.

l. 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.

m. 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.

n. Stock hanger and support components shall be used wherever practical.

o. 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. Ambient Systems
         1) B. 60 degrees F to 119 degrees F
      b. 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 1.08. The pipe system drawings specified in Section 40 05 07-1.05 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-58 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.

## 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 | --- | 10 | |
| 12 | 1 | 4960 | 20 | --- | --- | |
| 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 SHORTENED 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**

SECTION 40 05 19

DUCTILE IRON PIPE

## PART 1 GENERAL

### 1.01 SUMMARY

A. This Section specifies ductile iron pipe, joints, fittings, linings, and coatings.

### 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 06 – Specialty Couplings and Adapters

### 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 – External 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 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 01 and related sections.

## 2.02 DUCTILE IRON PIPE.

A. Manufacturers meeting qualifications as specified in this Section.

B. Type:
   1. In accordance with AWWA C150 and AWWA C151
   2. Pressure class and thickness as indicated in the Piping Schedule in the Drawings.

3. Manufactured from greater than 90 percent recycled material

## 2.03 FITTINGS

A. Ductile iron in accordance with AWWA C110 or AWWA C153

B. Joint type shall be as specified, shall be the same as associated piping, and shall be per the Piping Schedule in the Drawings.

C. Grooved end fittings shall be an accordance with AWWA C606 and have a rigid radius cut groove.

## 2.04 PIPE AND FITTING LINING

A. Provide pipe and fittings with lining as specified in the Piping Schedule in 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. Glass Lining.
      a. Factory or Shop applied.
      b. Line pipe and fittings with glass lining, 10 mils minimum thickness, using a dual layer coating system of vitreous material.
      c. Provide continuous coverage glass lining 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.
      d. Pipe bored, machined, or grit blasted to remove any voids, protrusions or surface irregularities and to obtain a smooth continuous surface for glass lining. Fittings shall be ground or grit blasted to remove any voids, protrusions or surface irregularities.
      e. Damaged glass lining cannot be repaired. Damaged glass lined pipe must be replaced.
      f. Candidate manufacturers:
         1) Ferrock, MEH 32.
         2) Vitco SG 14.
         3) CBGL911.
         4) Approved equal.
   3. 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

4. Unlined
   a. Provide pipe and fittings with a bare metal (no coating) interior.

## 2.05 PIPE COATING

A. Provide pipe with coating as specified in the Piping Schedule in the Drawings. 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.

## 2.06 FUSION-BONDED EPOXY LINING AND COATING FOR FITTINGS

A. Factory or shop applied.

B. Fusion Bonded Epoxy lining and coating per AWWA C116.

## 2.07 JOINTS, AND COUPLINGS

A. Flanged Joint
   1. Unless otherwise specified, flanges shall be ductile iron and shall be threaded-on flanges conforming to ANSI/AWWA A21.15/C115 or cast-on flanges conforming to ANSI/AWWA A21.10/C110. Flanges shall be adequate for 250 psi working pressure. Bolt circle and bolt holes shall match those of ANSI B16.1, Class 125 flanges and ANSI B16.5, Class 150 flanges. Where specified, flanges shall be threaded-on or cast-on flanges conforming to ANSI B16.1, Class 250.
   2. Bolts, nuts, and gaskets as specified in Section 40 05 06.16.

B. 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

C. 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

D. Mechanical Joint (MJ)
   1. Mechanical Joints per AWWA C110 and AWWA C111.
   2. Mechanical joints are not acceptable in above ground applications.

E. 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, Bolt-Lok or Mech-Lok (Mech-Lok for above ground applications only)
    c. Approved Equal

F. Grooved couplings (CGRV) and fittings.
1. In accordance with AWWA C606. 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

G. 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.

H. 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 the Piping Schedule and 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 24

STEEL PROCESS PIPE

## PART 1 GENERAL

### 1.01 SUMMARY

A. This section specifies steel pipe 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 40 05 01 – Piping Systems
   2. Section 40 05 06.16 – Piping Connections

### 1.03 REFERENCE STANDARDS

A. 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.

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 was 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. In all cases, the effective version of the local building code at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

| 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 |

| Reference | Title |
|---|---|
| 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 |
| 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 |

## 1.04 QUALITY ASSURANCE

A. 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.

## 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.

## 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.
   3. Lining shall be NSF-61 certified for potable water service.

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.

## 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 06.16.

## 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.
   2. Sleeve-type mechanical pipe couplings shall be provided in accordance with AWWA M11.
   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.

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**

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 33 – 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. ASTM D2321 - Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
   4. ASTM D2513 - Polyethylene Gas Pressure Pipe, Tubing, and Fittings
   5. ASTM D2657 - Heat Joining Polyolefin Pipe and Fittings
   6. ASTM D2774 - Underground Installation of Thermoplastic Pressure Piping
   7. ASTM D3035 – Polyethylene Plastic Pipe Based on Controlled Outside Diameter
   8. ASTM D3261 - Butt Heat Fusion Polyethylene Plastic Fittings for PE Plastic Pipe and Tubing
   9. ASTM D3350 - Polyethylene Plastics Pipe and Fitting Materials
   10. ASTM F1055 - Electrofusion Type Polyethylene Fittings for OD Controlled PE Pipe and Fittings
   11. ASTM F1668 - Construction Procedures for Buried Plastic Pipe
   12. ASTM F2164 - Standard Practice for Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure.
   13. ASTM F2206 - Fabricated Fittings of Butt-Fused Polyethylene

14. ASTM F2620 - Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
15. ASTM F714 - Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.
16. 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 01 33 00
   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 (see drawings).

## 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 (see drawings).

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Prevent damage to pipe from dragging over sharp objects or cutting by chokers or lifting equipment while handling pipe.

C. Handle pipe in accordance with pipe manufacturer's recommendations.

D. Pipe with gouges, cuts, or scratches deeper than 10% of the pipe wall thickness will be rejected.

E. Pipe with cuts, gouges, and/or scratches of the pipe interior will be rejected.

F. Store pipe in accordance with pipe manufacturer's recommendations until installation.

G. Store pipe at ambient outdoor temperature.

H. Provide temporary shading.

I. 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 Section and in the Piping System Schedules (see drawings).

B. Pipe Color:
   1. Black
   2. Where specified in the Piping System Schedules (see 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

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 23 00.

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.

**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 and valves.

### 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

### 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 61 45 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 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. 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.

## 2.02 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 according to ASME A13.1 and labelled with the Process Service Identifier and directional flow arrows indicating the direction of flow in the pipe. . 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.

## 2.03 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: BYP

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 57.23

ELECTRIC MOTOR ACTUATORS

## PART 1 GENERAL

### 1.01 SUMMARY

A. This Section includes requirements for electric motor actuators to produce rotary and linear motion to activate quarter-turn and multi-turn valves and gates in open-close, throttling, and modulating services.

### 1.02 RELATED SECTIONS

A. Valve Schedule in the drawings.

### 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.

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, 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 |
|---|---|
| ANSI/AWWA C542-16 | Electric Motor Actuators for Valves and Slide Gates. |
| ANSI/NEMA 250 | Enclosures for Electrical Equipment (1,000 Volts Maximum). |
| ANSI/NEMA MG1 | Motor and Generators. |
| ANSI/NFPA 70 | National Electrical Code. |
| UL 429 | Electrically Operated Valves. |
| UL 1002 | Electrically Operated Valves for Use in Hazardous (Classified) Locations. |
| NEMA ICS-2 | Industrial Control Devices, Controllers and Assemblies |

## 1.04 DEFINITIONS:

A. Use ANSI/AWWA C542-16, Electric Motor Actuators for Valves and Slide Gates definitions, unless otherwise noted.

B. For purposes of this Section, the word “valve” refers to both valves and gates.

C. Electric motor actuators are defined using the following code system which appears in the actuator specification (ACTUSPEC) sheets:

| 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 |

D. Service:
   1. Modulating: Operation characterized by the continuous positioning of a valve betweeen between fully open and closed, in response to a continuous control signal.
   2. Open-Close or Isolation: To move valve to fully open or fully closed position in one continuous operation. Alternative terms used are ON-OFF and isolating.
   3. Throttling: Operation characterized by the deliberate and/or the infrequent movement of a valve to an intermediate position, between fully open and fully closed, and maintaining that position for periods of time.

## 1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility:
   1. Provide unit responsibility for the valve specified in the drawings and the electric motor actuator specified in this section.

B. Coordination:
   1. Data: Ensure the valve data is provided to the actuator manufacturer. Transmit the required torque or thrust, shaft diameter, thread characteristics (including right or left-hand), keyway dimensions, seating requirements (torque or position) for open and close.
   2. Conditions: Identify most adverse conditions to be encountered at any time when actuation is necessary.
      a. For multi-turn, the following additional data is required for actuator sizing:
         1) Maximum torque and thrust running load over the full cycle.
         2) Desired speed of actuation or stroking time.
         3) The stall torque or maximum thrust output of the actuator not to exceed the torque or thrust capability as determined by the valve manufacturer.
      b. For quarter-turn, the following additional data is required for actuator sizing:
         1) The required actuator torque over the full cycle of operation.
         2) Desired speed of actuation or stroking time.

## 1.06 SUBMITTALS

A. Procedures: Submittal shall be provided in accordance with Section 01 33 00 and the following:.

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 from Section requirements.
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, mark the drawing or drawings with "no changes required".
3. Manufacturer's catalog information and other data confirming conformance to design and material requirements.
4. Actuator Data Sheet: An information data sheet for each actuator showing required mounting, operating torque for driven equipment, torque capacity of actuator, actuator speed, associated valve torque ratings, motor data (power, hp; full load amps, locked rotor amps, rpm, duty rating). Provide actuator identification (tag) number clearly for each application on the actuator data sheet.
5. List of components being provided for each actuator.
6. Shop drawings:
    a. Actuator assembly.
    b. Dimensions.
    c. Electrical wiring diagrams.
7. Actuator sizing report correlating to the coupled valve or gate type, operating torque and specified safety factor.

C. Informational Submittals:

1. Application manuals for configuring and set up of actuator for control, monitoring and alarming.
2. Application software and software manuals for programming communication network bus when specified. Include electronic data sheet or generic station description files for network configuration.
3. Recommended storage practice. In addition, place this information on the outside of the actuator or shipping container as delivered to the site.

D. Closeout Submittals:

1. Operation and Maintenance Data: Submit manufacturer’s standard operating and maintenance instructions in accordance with Section 01 33 00.
2. Maintenance Material:
    a. Spare Part Inventory Listing.
    b. Spare Parts.
    c. Special Tools.
    d. Lubrication guide.
    e. Certified drawings.

3. Actuator Configuration Settings: The final settings used for configuration of the actuator to meet field operation requirements. Include both the electronic files and a hard copy printout in pdf format.

## 1.07 QUALITY ASSURANCE

A. Identification of Listed Products:
   1. Provide equipment and materials listed 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). Provide independent testing laboratory acceptable to the inspection authority having jurisdiction.

## 1.08 DELIVERY, STORAGE AND HANDLING

## 1.09 PROCEDURES:

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. Valves shall be handled, stored, and installed as recommended by the manufacturer. 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 according to Section 40 05 45.

## 1.10 WARRANTY

A. Manufacturer to warrant all actuators furnished under this Section against defects in materials and workmanship for a period of two years, unless otherwise specified.

# PART 2 PRODUCTS

## 2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the actuator specification (ACTUSPEC) sheets. The manufacturer's standard models or products may require modification to conform to the specified requirements.

## 2.02 PERFORMANCE

A. Size actuators to produce an operating torque equal to twice the maximum required valve operating torque under the specified flow and pressure conditions. Specific requirements for each type of actuator are specified on the actuator specification (ACTUSPEC) sheets located at the end of this Section.

B. Seat valve or stopping method based on valve manufacturer's recommendation:
   1. Torque
   2. Position/Limit

C. Ambient Temperature Range: -20 to +140 degree Fahrenheit (up to 100% relative humidity).

D. Travel Speed: Time required to open/close not to exceed 30 seconds.

E. Rotation:
   1. Quarter-Turn: 90 degrees, with +/- 5 degree adjustable mechanical travel stops. Stops designed to withstand maximum actuator torque.
   2. Multi-Turn: Position setting range of 2.5 to 8,000 turns with a minimum angular resolution of 7.5 degrees at the output.

## 2.03 CONFIGURATION, COMPONENTS AND FEATURES

A. General: Unless otherwise specified, provide electric motor actuators in accordance with the actuator specification (ACTUSPEC) sheets and the following requirements.

B. Motor:
   1. General:
      a. Specifically designed for valve actuator service.
      b. Totally-enclosed, non-ventilated construction.
      c. Compliance to ANSI/NEMA MG1.
   2. Duty Rating based on Actuator Service:
      a. Open-Close: 25% (15 minutes) or 50% (30 minutes) duty motor rated for minimum of 60 starts per hour.
   3. Motor Starter: Provide actuator with a full voltage reversing starter rated for the motor's locked rotor and full load currents for 10,000 cycles with mechanical and electrical interlocks and overload protection in each phase pole.
   4. Three Phase:
      a. Reversible, Squirrel Cage Motor.
         1) 460V, 3-phase, 60 Hz power with +/- 10 percent voltage fluctuation.
         2) Four-pole 1800 RPM or provide pole-speed as required for the application.
         3) NEMA Class F insulation.
         4) Thermistor or thermostat for thermal protection embedded in the motor windings.
         5) Automatic motor thermal reset once motor has cooled sufficiently after overload.
         6) Three conduit openings, minimum.
      b. Control Transformer:
         1) Epoxy encapsulated and impregnated with short-circuit and overload protection.
         2) Rated, at a minimum, to handle 80% of the connected load with 120VAC secondary or other secondary voltage of 24VDC as required.
         3) Adequately rated to provide power for the following functions:
            a. Energizing of the contactor coils.
            b. Internally sourced power for remote controls.
            c. Internal electrical circuits.
            d. Heater.

C. E

nclosure: Provide NEMA 250 electrical enclosures rated for the application and location specified:

1. Non-hazardous, indoor and outdoor locations.
    a. Type 4, Weatherproof.
    b. Type 4X, Corrosive.
    c. Type 6, Submersible for 6-foot head for 30 minutes.
2. Hazardous locations, indoor and outdoor locations.
    a. Type 4/7, Class I, Divisions 1 and 2, Groups C & D certification.
3. All external fasteners stainless steel.

D. Disconnect Switch: Provide a lockable, heavy-duty, NEMA 4X, non-fused, UL listed disconnect switch for mounting near actuator. Where actuated valve is out-of-reach, locate the disconnect switch on an adjacent wall at an accessible level.

1. Where depicted on the drawings provide auxilary contact. The contact to close when disconnect switch is in close position. The contact to open when disconnect switch is in open position.

E. Gearing:

1. Totally enclosed in an oil or grease filled gearcase suitable for operation at any angle.
2. All drive gearing and components must be of metal construction and machine cut.
3. For rising stem valve (multi-turn), provide hollow output shaft accepting a rising stem and incorporating thrust bearings of the ball or roller type at the base of the actuator. Permit the opening of the gearcase for inspection, and disassembly without releasing the stem thrust or taking the valve out of service.
4. For quarter-turn, self-locking drive gearing to prevent the valve back-driving the actuator. Multi-turn actuator combined with part-turn gearbox for 90-degree rotation can be used for high torque applications or for large nominal diameter quarter-turn valves being used for isolating, throttling or modulating service.
5. Design all gearing to withstand a 100% overload.

F. Torque Switches: Provide electric motor actuators with a double-torque switch set to disengage motor power at 40 to 100% of actuator rated torque and less than 75% of the shaft's design torque. Operate the torque switch in both the opening and closing directions and operate during the complete cycle without the use of auxiliary relays, linkages, latches, or other devices.

1. Provide each side of the torque switch with set point adjustment. Mount a calibration tag near each switch for correlating the settings with output torque activation.

G. Position Switches: Provide electrical or electro-mechanical confirmation of valve position. Position limit switches to indicate various positions between the fully opened and fully closed. Provide limit switches for visual local position indication of the valve and for extermal position monitoring through solid-state relay or electro-mechanical relays. Provide at least four relays with dry contacts for external position monitoring.

H. Hammer Blow Device: Provide electric motor actuators with a built-in lost-motion device that allows sufficient travel of the motor, prior to engaging the stem nut, for the motor to reach full speed. This action to impart a "hammer blow" to start the valve in motion in either direction. Share the load equally by two lugs cast integrally on the drive sleeve.

I. Handwheel: Provide electric motor actuators with a handwheel for manual operation. Do not rotate the handwheel during motor operation. Do not prevent handwheel operation when motor is locked. Accomplish motor or manual selection by a positive declutching knob or lever which disengages the motor and motor gearing mechanically but not electrically. Prohibit manual and motor simultaneous operation. Do not require more than 80 pounds of rim effort at maximum torque for hand operation.

## 2.04 CONTROL PANEL

A. Provide a remote-mounted local control station along with an integral operator control unit, either which can serve as a control station for each actuator, unless otherwise specified.

B. The remove-mounted and integral control stations to include pilot devices:
   1. LOCAL, OFF, REMOTE, STOP, OPEN, and CLOSE controls through selector switches and/or pushbuttons.
      a. In LOCAL, use the control station's OPEN and CLOSE devices to position the valve to full open or full close. Configure for inching "maintained or sealed in" action in either travel direction.
      b. For REMOTE mode, both the remote and integral control stations are to be in REMOTE:
         1) Open-Close (Isolating) Service:
            a) Contacts Closure: Use momentary operation of external OPEN or CLOSE contacts to open and close the valve.
         2) Prevent the controls station's local OPEN and CLOSE devices from operating the valve.
      c. In STOP, prevent travel in either open or close direction in both LOCAL and REMOTE.
   2. Indication:
      a. OPEN and CLOSE Status Lights: Color of lights [per Division 26] [green][red] for full open and [red][green] for full close].
      b.

C. Location of Control Station:
   1. Local: NEMA 4X/7 Control station factory mounted directly to the electric motor actuator.
   2. Remote: NEMA 4X/7 Control station mounted separate from the electric motor actuator where specified. Provide one of the following options:
      a. Add another control station if the factory mounted control station can not be detached from the electric motor actuator. If two control stations are provided then both control stations must have identical operations.
      b. Remote mount the entire actuator control package compartment including control power transformers, motor contactors and positioners.

D. External Monitoring:
   1. Status and Alarms: Provide single pole double throw (SPDT) or single pole single throw (SPST) dry contacts rated at 0.5 amps for 24VDC, and 3A for 120VAC. Provide contacts as normally open or normally closed:

a. Open Status: Representing valve in full open position.
b. Close Status: Representing valve in full close position.
c. Remote Status: LOR in Remote, representing actuator operation from external source enabled.
d. Local Status: LOR in Local, representing actuator operation from the control station enabled.
e. Alarm Status: Representing valve or actuator trouble.

2.

## 2.05 CONFIGURATION

A. Features:
1. Non-intrusive or wireless access to view and setup the actuator parameters.
2. Transfer diagnostic data logged in the actuator memory to a personal computer (PC).
3. PC graphical user interface software allowing actuator set-up configuration and data logging information to be reviewed, analyzed and reconfigured.

## 2.06 NAMEPLATES

A. Control Station: Provide nameplates for each control station.
1. Functional Nameplate: Engrave a white phenolic plate with black 5/32-inch-high lettering with valve functional description and valve equipment number as specified or shown. Permanantly fasten functional nameplate to control station. Nameplate wording may be changed without additional cost or time, if changes are made prior to commencement of engraving.
2. Marking Nameplate: Engrave or stamped stainless steel. Permanantly fasten nameplate to the control station. Provide the information on nameplate as required by NFPA 70 (NEC) for industrial control panel markings.

B. Motor: Engrave or stamped stainless steel. Permanantly fasten nameplate to the motor frame and ensure visibly positioned for inspection. Provide the information on nameplate as required by NFPA 70 (NEC).

C. Actuator: Engrave or stamped stainless steel. Provide the following information on nameplate: manufacturer, model number, serial number, ambient temperatrure minimum/maximum, rated torque, and opening time.

## 2.07 ASSEMBLY/FABRICATION

A. Factory-mount electric motor actuators on the valve as a unit. Provide each valve body or actuator with the word "OPEN” cast thereon, an arrow indicating the direction to open, and flow direction arrows.

## PART 3 EXECUTION

### 3.01 PREPARATION

A. Prior to installation of the electric motor actuator assemblies, field measure and check all equipment locations, pipe alignments, and structural installations. Ensure that sufficient space and accessibility is available for electric motor actuators.

### 3.02 INSTALLATION

A. Equipment Mounting.
   1. Locate actuator with unobstructed access for operation and maintenance.
      a. Do not obstruct walkways.
      b. Do not attach to handrails, process piping, or mechanical equipment.
      c. Do not locate where shock or vibration impairs its operation.
   2. Locate remote control station with unobstructed access for operation and maintenance between 48 inches and 60 inches above the floor or a permanent work platform, and within site of the actuator.
   3. Mount actuators to have their manual operating accessory, where possible, located between 48 inches and 60 inches above the floor or a permanent work platform.

B. Nameplates: Locate nameplates in a clearly visible location. If necessary, reposition and reattach with stainless steel screws or wire.
   1. Electrical Interconnection: Comply with Division 26 for power wiring, control wiring and signal wiring.

### 3.03 FIELD QUALITY CONTROL

A. Provide a factory-trained manufacturer's representative at the site for the following activities.
   1. Inspect actuator's electrical power, control, signal, communication and grounding wiring for proper termination.
   2. Configure actuator and include:
      a. Actuator Settings: Limit switch, torque position, travel speed, emergency shutdown function, loss of position signal function, and relay functions.

### 3.04 SYSTEM START UP

A. General Requirements:
   1. Perform testing in accordance with Section 01 45 20, and this Section. Apply no required test without prior notice to the Construction Manager to witness any test. At least 14 days before the commencement of any testing activity, provide a detailed step-by-step test procedure, complete with forms for the recording of test results. Provide all equipment necessary to perform the required tests.
   2. Test each electric motor actuator for each mode of operation including but not limited to both local and remote- open, close, stop, emergency shutdown, position control,and network operation, as well as, the travel rates, limit switches, jam and torque settings, and loss of control signals. Provide testing collaboration for remote operation with Section 40 61 21.

3. Ensure electric motor actuator control can be re-initiated locally and remotely after power loss recovery without faulting.
4. Provide a factory-trained manufacturer's representative at the site to re-adjust actuator setting under normal operating conditions with the specified design process fluid.

## 3.05 TRAINING

A. Provide operation and maintenance training for the equipment provided under this Section for the Owner's personnel taught by a factory-trained manufacturer's representative.

B. Include in training sessions preventive maintenance requirements, overhaul and troubleshooting instructions, normal operating practices, actuator parameter configuration set-up, and changing actuator parameter settings.

## PART 4 APPENDIX – ACTUSPECS

## 4.01 ACTUATOR SPECIFICATION SHEETS (ACTUSPEC)

A. General requirements for actuators specified in this Section are listed on ACTUSPEC sheets herein.

**Table A**

| ACTUSPEC Symbol | Actuator Description | Actuator Service Power |
|---|---|---|
| EQTI | Electric Quarter-Turn Actuator for Isolating (Open-Close) Service | 480VAC, 3-phase |

## 4.02 ACTUATOR IDENTIFICATION: EQTI (480V)

A. Actuator Description: Electric Quarter-Turn Actuator or Multi-Turn Actuator with 90-Degree Gearbox for Isolation Service.

B. Manufacturers:
1. Rotork, IQT or IQ Pro Series.
2. Limitorque, MXA.
3. EIM, Series 2000.
4. AUMA, SG, SA/GS or SQ.
5. Or approved equal.

C. Features:
1. Power Supply: 480VAC, 3-phase, 60 Hz.
2. Controller: An unfused disconnect type combination starter in compliance with NEMA ICS.
3. Controls:
   a. Power Source: Internal or external 120VAC or 24VDC.
   b. Remote Control Type: Contact Closure.

c. Emergency Shutdown: A minimum of one independent signal when applied to the actuator overrides any existing command signal and sends valve in a preselected shut down position.

d. Location of Control Station: Remote unless otherwised specified.

4. Gear Train: 90-degree gear box.

**END OF SECTION**

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40 05 64.05

BUTTERFLY VALVE, AWWA C504, CLASS 150B

**GENERAL**

1. Line Size: 3 through 72 inches
2. Rated Limits: Pressure 125 psi; Temperature 120 °F

**VALVE MATERIALS**

1. Body: Cast Iron or Ductile Iron
2. Disc: Cast Iron or Ductile Iron; 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
3. Disc Trim: Stainless Steel (304) or Nickel
4. Seats: Neoprene, EPDM, or Buna-N; 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
5. Shaft: Stainless Steel (304 or 316)

**VALVE CONFIGURATION**

1. Valve End/Connections: Flange, ASNI B16.1 Class 125
2. Type of Disc: Eccentric
3. Manual Operator: Handwheel; provide geared operators for valves 6 inches and larger
4. Reference Standard: AWWA C504

**SUBMITTALS**

1. Action Submittals:
   a. Manufacturer's data including product literature, materials of construction, construction details of equipment, wiring diagrams, and weight of equipment.
   b. Affidavits of compliance with AWWA C504.

**CANDIDATE MANUFACTURERS**

1. Homestead Series 820
2. DuZurik BAW
3. Pratt XR-70

**END OF SECTION**

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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.

B. System overview. Detailed requirements are in individual related specification sections.
   1. Field Instrumentation:
      a. New field instruments.
   2. Process Control Hardware:
      a. Integration of an existing control system.
      b. Programmable logic controllers (PLC)
      c. New local control stations
   3. Process Control Software, Programming, and Integration:
      a. Control software, programming and integration is to be performed by the Design Professional under a separate construction services task
   4. Communications and Networking
      a. Wireless communications systems
      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.

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. HIM: human interface module
   2. HMI: human-machine interface
   3. OIT: operator interface terminal
   4. PCS: plant control system
   5. PICS: Process and Instrumentation Control System
   6. PLC: programmable logic controller
   7. SCADA: supervisory control and data acquisition

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 (mA) regulated signal in a series circuit with a 24 volt direct current (VDC) driving potential and a maximum circuit resistance of 600 ohms (Ω).
   4. Four-wire transmitter: A transducer that derives operating power from separate power supply connections. A four-wire transmitter produces a 4 to 20 mA current regulated signal in a series circuit with a maximum circuit resistance of 600 Ω. 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 (mV) or less including thermocouples and resistance temperature detectors.
   2. Analog, high level: Signals with full output level greater than 100 mV but less than 30 volts, including 4 to 20 mA transmission.
   3. Discrete control or events: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits.
   4. 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 mA
   5. Pulse frequency: Counting pulses emitted from speed or flow transmitters.
   6. Radio frequency (RF) signals: Continuous wave alternating current signals with fundamental frequency greater in a range of 310 kilohertz (kHz) to 300 gigahertz (GHz).

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 Diagramson the drawings.
   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.

## 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 AutoCAD version 2017 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".
         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 (✓) 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, at a minimum:
            a) Network system block diagrams

b) Cabinet and panel arrangement drawings
c) Control single-line diagrams
d) Process and instrumentation diagrams
e) Loop diagrams
f) Equipment 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 33 00.
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.
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. Project personnel qualifications per paragraph 1.08, Quality Assurance.

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

## 1.08 ENVIRONMENTAL CONDITIONS

A. Ambient conditions: Per Section 01 11 80

B. Corrosive locations: Per Division 26.

C. Hazardous (Classified) areas: Per Division 26 and on the contract drawings.

D. Seismic:
   1. Brace equipment and supports per Section 01 73 24 or Structural Drawings.

# PART 2 PRODUCTS

## 2.01 [CONTROL SYSTEM

A. Manufacturers:
   1. Xx
   2. Xx
   3. xx
   4. [Product Options: Development of the contract documents is based on _____]

B. Description:
   1. Xx
   2. Xx

C. Performance/Design Criteria:
   1. Xx
   2. Xx]

## 2.02 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: [hot-dip galvanized after fabrication] or[ shall be 316L stainless steel], as shown or specified.

## 2.03 SOFTWARE

A. Software shall be addressed as part of the construction services tasks.

## 2.04 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: 316 stainless steel |
| Indoor: corrosive area | NEMA 4X: compatible with environment |
| Outdoor: corrosive area | NEMA 4X: compatible with environment |
| 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. |

## 2.05 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 white letters on black 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. 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.
   3. 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.

4. Nameplates shall be provided for all field-mounted equipment. Nameplates shall be attached to support hardware with a minimum of two self-tapping Type 316 stainless steel screws in a readily visible location, but such that if the field device is changed out, the nameplate will remain to identify the service.

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 120VAC 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 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.

## 3.04 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.

**END OF SECTION**

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. Loop testing.
4. Functional testing.
5. 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 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. 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.
   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. Separate submittals may be provided for each process area or test group:
         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.

C. Closeout Submittals
   1. Final Test Report assembled in a three-ring binder 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. Performance test results.

f. Loop test results.
g. Functional test results.
h. Operational test results.

## 1.05 QUALITY ASSURANCE

A. Appoint a startup engineer or qualified specialist as PICS Testing Manager to manage, coordinate, and supervise the testing work.

B. The quality assurance program includes:
   1. Definition of process areas and systems, with testing executed on an area-by-area basis, based on the P&ID drawings.
   2. Testing for each process area executed in sequential tasks.
   3. Regularly updated testing status tracking by process area, system, and task.
   4. Regularly updated separate testing documentation for each process system.

C. PICS Testing Manager Qualifications:
   1. The PICS Testing Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the testing and startup of similar electrical and instrumentation control systems.

D. Testing Technician Qualifications:
   1. Employ technicians who are qualified by completion and certification from training courses offered by the International Society of Automation (ISA), the instrumentation and analyzer manufacturer's training courses, or technician training courses at a recognized trade school that specializes in instrumentation calibration.

# PART 2 PRODUCTS

NOT USED

# 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.

C. Performance Deviation Tolerances:
   1. Tolerances are specified in individual sections. Where tolerances are not specified, refer to the manufacturer's published performance specifications.

D. Witnessing:
   1. The Engineer reserves the right to observe instrumentation testing and calibration procedures. Notify the Engineer prior to testing.

## 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.
      a. Power and Control: Section 26 08 00.
      b. Signal: Section 40 61 13-Form A.

C. Instrumentation Calibration:
   1. Calibrate instruments and final elements in accordance with the manufacturer's recommended procedures and tested in accordance with the Contractor's test procedure.
   2. Complete and document instruments and component inspections to the satisfaction of the Engineer prior to individual component calibration and testing.
   3. Calibrate analog instrument at 0, 10, 50, 90, and 100 percent of the specified full-scale range. Adjust each signal sensing trip and process sensing switch to the required setting. Verify instrument readout matches loop signal. Test data recorded on test forms as specified herein.
   4. Test and adjust final element alignment to verify that each final element operates smoothly over the full range in response to the specified process control signals.
   5. Have any component repaired or replaced by the manufacturer where the component fails to meet the required tolerances. Repeat the specified tests until the component is within tolerance.

6. Install a calibration sticker on each instrument following successful calibration that indicates the date of calibration, the name of the testing company, and personnel who calibrated the instrument.

D. 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 Engineer.

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. 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. 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**

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 – Process Control System General Provisions.
   2. Refer to Section 40 61 21 – Process Control System Testing.

### 1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Submittal grouping: Section 40 61 13.
   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. 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. 40 61 93.50 Attachment A: Input/Output (I/O) List

1. Description of headings in Input/Output (I/O) List.

| Field or Heading | Example | Comment or Description |
|---|---|---|
| Item | 001 | See tagging on instrument legend sheets |
| Area | 50 | See tagging on instrument legend sheets |
| Loop No. | 0331 | See tagging on instrument legend sheets |
| Function Abbreviation and Loop No. | YN0326 | See tagging on instrument legend sheets |
| Description | | See tagging on instrument legend sheets |
| P&ID | 50-PI-01 | See tagging on instrument legend sheets |
| Control Spec | | See tagging on instrument legend sheets |
| PLC/RIO | GEN FILTER | Number or tag to match contract documents |
| I/O Type | DI | AI, DI, DO, AO |
| Module/Device Type | 24VDC | 120V or 24VDC |
| Rack | 03 | Match contract drawing, or if not shown, match to submittal information |
| Slot | 07 | Match contract drawing, or if not shown, match to submittal information |
| Point | 03 | Match contract drawing, or if not shown, match to submittal information |
| I/O Wiring Detail/Diagram | | Match contract drawing, or if not shown, match to submittal information |
| Application Notes | | Match contract drawing, or if not shown, match to submittal information |

**END OF SECTION**

| Item | Area | Loop Number | Tag | Description | P&ID | CONTROLSPEC | PLC/RIO | I/O Type | Module/Device Type | Rack | Slot | Point | I/O Wiring Detail/Diagram | Application Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | 50 | 0331 | ZLO0331 | FLOCCULATOR 2A INLET VALVE OPENED | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 002 | | 0331 | ZLC0331 | FLOCCULATOR 2A INLET VALVE CLOSED | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 003 | | 0331 | EI0331 | FLOCCULATOR 2A INLET VALVE IN AUTO | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 004 | | 0331 | YA0331 | FLOCCULATOR 2A INLET VALVE FAIL | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 005 | | 0326 | EI0326 | FLOCCULATOR 2A VFD IN REMOTE | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 006 | | 0326 | YN0326 | FLOCCULATOR 2A VFD RUNNING | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 007 | | 0326 | YA0326 | FLOCCULATOR 2A VFD FAIL | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 008 | | 0327 | EI0327 | FLOCCULATOR 2B VFD IN REMOTE | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 009 | | 0327 | YN0327 | FLOCCULATOR 2B VFD RUNNING | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 010 | | 0327 | YA0327 | FLOCCULATOR 2B VFD FAIL | 50-PI-01 | | GEN FILTER | DI | 24VDC | | | | | |
| 011 | 50 | 0332 | ZLO0332 | FLOCCULATOR 1A INLET VALVE OPENED | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 012 | | 0332 | ZLC0332 | FLOCCULATOR 1A INLET VALVE CLOSED | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 013 | | 0332 | EI0332 | FLOCCULATOR 1A INLET VALVE IN AUTO | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 014 | | 0332 | YA0332 | FLOCCULATOR 1A INLET VALVE FAIL | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 015 | | 0328 | EI0328 | FLOCCULATOR 1A VFD IN REMOTE | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 016 | | 0328 | YN0328 | FLOCCULATOR 1A VFD RUNNING | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 017 | | 0328 | YA0328 | FLOCCULATOR 1A VFD FAIL | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 018 | | 0329 | EI0329 | FLOCCULATOR 1B VFD IN REMOTE | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 019 | | 0329 | YN0329 | FLOCCULATOR 1B VFD RUNNING | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 020 | | 0329 | YA0329 | FLOCCULATOR 1B VFD FAIL | 50-PI-02 | | GEN FILTER | DI | 24VDC | | | | | |
| 021 | | 0331 | ZCO0331 | FLOCCULATOR 2A INLET VALVE OPEN COMMAND | 50-PI-01 | | GEN FILTER | DO | 24VDC | | | | | |
| 022 | | 0331 | ZCC0331 | FLOCCULATOR 2A INLET VALVE CLOSE COMMAND | 50-PI-01 | | GEN FILTER | DO | 24VDC | | | | | |
| 023 | | 0332 | ZCO0332 | FLOCCULATOR 1A INLET VALVE OPEN COMMAND | 50-PI-02 | | GEN FILTER | DO | 24VDC | | | | | |
| 024 | | 0332 | ZCC0332 | FLOCCULATOR 1A INLET VALVE CLOSE COMMAND | 50-PI-02 | | GEN FILTER | DO | 24VDC | | | | | |
| 025 | | 0326 | YC0326 | FLOCCULATOR 2A VFD START COMMAND | 50-PI-01 | | GEN FILTER | DO | 24VDC | | | | | |
| 026 | | 0327 | YC0327 | FLOCCULATOR 2B VFD START COMMAND | 50-PI-01 | | GEN FILTER | DO | 24VDC | | | | | |
| 027 | | 0328 | YC0328 | FLOCCULATOR 1A VFD START COMMAND | 50-PI-02 | | GEN FILTER | DO | 24VDC | | | | | |
| 028 | | 0329 | YC0329 | FLOCCULATOR 1B VFD START COMMAND | 50-PI-02 | | GEN FILTER | DO | 24VDC | | | | | |
| 029 | | 0326 | SI0326 | FLOCCULATOR 2A VFD SPEED | 50-PI-01 | | GEN FILTER | AI | 4-20 mA | | | | | |
| 030 | | 0327 | SI0327 | FLOCCULATOR 2B VFD SPEED | 50-PI-01 | | GEN FILTER | AI | 4-20 mA | | | | | |
| 031 | | 0328 | SI0328 | FLOCCULATOR 1A VFD SPEED | 50-PI-02 | | GEN FILTER | AI | 4-20 mA | | | | | |
| 032 | | 0329 | SI0329 | FLOCCULATOR 1B VFD SPEED | 50-PI-02 | | GEN FILTER | AI | 4-20 mA | | | | | |
| 033 | | 0326 | SC0326 | FLOCCULATOR 2A VFD SPEED SETPOINT | 50-PI-01 | | GEN FILTER | AO | 4-20 mA | | | | | |
| 034 | | 0327 | SC0327 | FLOCCULATOR 2B VFD SPEED SETPOINT | 50-PI-01 | | GEN FILTER | AO | 4-20 mA | | | | | |
| 035 | | 0328 | SC0328 | FLOCCULATOR 1A VFD SPEED SETPOINT | 50-PI-02 | | GEN FILTER | AO | 4-20 mA | | | | | |
| 036 | | 0329 | SC0329 | FLOCCULATOR 1B VFD SPEED SETPOINT | 50-PI-02 | | GEN FILTER | AO | 4-20 mA | | | | | |

SECTION 40 61 96

PROCESS CONTROL DESCRIPTIONS

## PART 1 GENERAL

### 1.01 SUMMARY

A. SCOPE: 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, startup, and checkout. They describe how the system is to operate, and do not necessarily include every component required to make the system function.

1. Control strategies describe sequential and interlocking control functions, analog control functions, color-graphic video display HMI Computers and Operator Interfaces and alarm and event logging. The System Programmer will provide all necessary software and applications programming to implement the control strategies. All control functions shall be programmed in the PLCs, the Operator Interfaces and HMI computers shall perform supervisory functions.
2. The Engineer will be responsible for configuring and/or programming of the PLC(s), Operator Interface(s), and HMI computer screens for the existing SCADA/HMI. The Engineer will also configure the the existing HMI process graphic displays, equipment statuses, and alarming requirements for the new and/or repurposed process equipment.

### 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. Programming: Refer to Section 40 61 13.

### 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. 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 5.06.01 | Functional Requirements Documentation for Control Software |
| ANSI/ISA 101.01 | Human Machine Interfaces for Process Automation |

## 1.04 DEFINITIONS

1. Per ANSI/ISA 5.06.01:
   a. Analog Input (AI): A modulated signal received by the control system from an external device, such as a 4-20 mA or fieldbus signal from a pressure transmitter.
   b. Analog Output (AO): A modulated signal sent by the control system to an external control device, such as a 4-20 mA or fieldbus signal to a flow control valve.
   c. Discrete Input (DI): A binary signal received by the control system from an external switch, such as a 24VDC or fieldbus signal from a block valve's closed limit switch.
   d. Discrete Output (DO): A binary signal sent by the control system to an external on/off device, such as a 120VAC or fieldbus signal to start a pump.
   e. Operation: A major programmed processing action or set of related actions normally consisting of one or more phases.
   f. Piping and Instrumentation Diagram (P&ID): A diagram showing the interconnection of process equipment and instrumentation used to control a process,
   g. Process Flow Diagram (PFD): A diagram showing outlines of one or more pieces of equipment and the expected flow paths for materials and utilities.
   h. Phase: The smallest element of procedural control that can accomplish a process-oriented task. A phase may be comprised of steps.
   i. Step: Sequential action of control devices within a phase.
2. Per ANSI/ISA 101.01:
   a. Control System: A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner.
   b. Human Machine Interface (HMI): The collection of hardware and software used by the operator or other users to monitor and interact with the control system and with the process via the control system.
   c. Supervisory Control and Data Acquisition (SCADA): A system for monitoring and control of process which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.
3. For the purposes of this section, "Existing" refers to those structures, devices, or items of equipment which were a part of the process system prior to the work done under this Contract

## 1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordinate with the Engineer as specified in Section 40 61 13 for testing and commissioning.

## 1.06 SUBMITTALS

A. PROCEDURES:
   1. Section 01 33 00.

B. ACTION SUBMITTALS:
   1. Conformance with specification per Section 40 61 13.

C. CLOSEOUT SUBMITTALS:
   1. .

## PART 2 NOT USED

## PART 3 EXECUTION

## 3.01 CONTROL STRATEGIES

A. The following control strategies are included in this section and describe general control features for all systems.

| Control Strategy Number | Title |
|---|---|
| 1 | Discrete Point Status |
| 2 | Analog Point Status |
| 3 | General Ready, Running and Failure Status |
| 4 | General Recording System |
| 5 | General Contact/Logic System |
| 6 | General Process Control Function (Analog) System |
| 7 | Trend Plots |
| 8 | Color Notation for Dynamic Objects on Control Graphic Display Screens |
| 9 | Discrete Alarm System |
| 10 | Discrete Status System |
| 11 | Variable Frequency Interface Signals |
| 12 | Flocculators |

B. Refer to related sections for detailed process control system descriptions.

**Control Strategy 1**
**Discrete Point Status**

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. The status of each discrete input point shall be maintained in the SCADA system database. The status of each logical discrete point shall also be maintained in the SCADA system database. Logical points are points which depend upon the status of one or several discrete input points.
   2. For example, an 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.

D. SCADA:
   1. Calculate and maintain the status of all discrete and logical discrete status points in the SCADA system database.

**End of Control Strategy 1**

**Control Strategy 2**
**Analog Point Status**

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. Analog input points shall be checked for the following status conditions:
      a. Failed: Point value is less than or greater than the specified value range, typically less than 3.6 mA and greater than 21.6 mA.
      b. Low Alarm: Point value is equal to or less than a predetermined alarm value.
      c. High Alarm: Point value is equal to or greater than a predetermined alarm value.
      d. Normal: Point value is within the predetermined low and high alarm values.
   2. An analog point which is in alarm status shall not be changed to normal status until the point value changes by the predetermined deadband value for the point.

D. SCADA:
   1. Failed, high alarm, low alarm, and deadband values shall be maintained in the SCADA system database. These limits may be changed via the SCADA programmer.
   2. Point status shall be maintained in the SCADA system database. Discrete alarm outputs shall be driven from the point status.

**End of Control Strategy 2**

## Control Strategy 3
## General Ready, Running and Failure System

A. Each motor-driven piece of equipment shall have a RUNNING status input to the SCADA system. If the equipment is equipped with one or more LOCAL-OFF-REMOTE switches, the equipment shall have an input for REMOTE status. If a “RUNNING” input status occurs and the “REMOTE” status does not occur, the SCADA system shall identify that the motor is operating in the LOCAL mode.

B. The run time shall be calculated and stored for all equipment being monitored. This function shall be equivalent to a conventional elapsed time meter to include the tenth of an hour digit. Program a setpoint to set a flag for maintenance of equipment. Program an adjustable timer to set a flag for maintenance of equipment. A summary of equipment requiring maintenance shall be printed out upon plant operator request.

C. The failure of driven equipment shall be monitored by the SCADA system. Equipment shall be considered failed under the following conditions:
   1. The equipment is in AUTO and the SCADA system attempts to operate the equipment and it does not respond within a defined time period.
   2. The equipment is in AUTO and running and for whatever reason other than the SCADA system requesting the equipment to “STOP,” the equipment stops.

D. In addition, specific equipment is required to provide “Trouble”, “Fault”, or other specific alarm inputs to the SCADA system. This input shall be added to the internal logic described in items 1 and 2 above so that any one of these events shall trigger a “FAIL” alarm.

E. The SCADA system shall be used to the extent that it shall facilitate sequencing of the equipment. The plant operator shall be able to bypass the sequencing and START/STOP the equipment and OPEN/CLOSE valves and gates on a “MANUAL” procedure from the hand switches when desired. Interface to the SCADA system shall be through I/O points or workstations or laptops.

**End of Control Strategy 3**

## Control Strategy 4
## General Recording System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall generate reports based upon process variables (pressure, flow, temperature, level and analytical) and equipment status (speed, and motor current) in real-time and from recent historical data. The exact report requirements will be determined by the Owner and shall be configured by the System Programmer during the project construction period.
   2. All instruments shown on the P&IDs with PIR-xxxx. FIR-xxxx, TIR-xxxx, LIR-xxxx, and AIR-xxxx shall also be included under this recording requirement (where xxxx indicates instrument tag number).

**End of Control Strategy 4**

**Control Strategy 5**
**General Contact/Logic System**

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All discrete/logic control functions shall be provided as required and shall include but not be limited to the following:
      a. Discrete/Logic Functions: The ability to perform logic and sequencing functions shall be supported to provide control interlocks, event sequencing and other logic operations.
      b. Boolean Algebra requirements: AND gate, OR gate, NAND gate, NOR gate, XOR gate, and NXOR gate.
      c. Logic requirements: Logic switch, logic compare, bi-directional time delay, and on-off with feedback.
      d. Ladder Logic requirements: NO contact, NC contact, energize coil, latch/unlatch coil, retentive timer on/off delay, up/down counter, counter/timer reset, ladder execution control, immediate input, and immediate output.

**End of Control Strategy 6**

## Control Strategy 6
## General Process Control Function (Analog) System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All analog control functions shall be provided as required and shall include but not be limited to the following:
      a. 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 shall be available.
      b. HMI display system shall have a common PID controller operator interface for all equipment utilizing PID control. Controller operator interface shall include alphanumeric and graphic indication of the following features as a minimum:
         1) ID of controlled equipment
         2) ID of process variable input
         3) Controller setpoint value
         4) Process variable value
         5) Controller output value
         6) Setpoint adjustment interface
         7) Indication if setpoint is under local or remote control
         8) Local/Manual control output adjustment interface
         9) Indication if control output is under local/manual control or under that of a process controller
      c. Computational Functions: On-line mathematical functions shall be available to provide real-time computational capability of control variables for use in feed-forward and other advanced control functions.
      d. All setpoints for alarm and control shall be adjustable from password-protected HMI Computer screens. Coordinate level of security required for password protection of setpoint screens with the Owner and Engineer.
      e. Appropriate control action(s) shall be provided as needed.

**End of Control Strategy 6**

## Control Strategy 7
## Trend Plots

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall graphically plot trends of process variables (pressure, flow, temperature, level and analytical), controller setpoints and outputs, and equipment status (speed and motor current) in real-time and from historical data. The plant operator shall be able to select the plotting interval, within the limits of the actual data collection. Provide a minimum of four trends per display view.
   2. In addition to the plotted data, a trend shall include:
      a. Time
      b. Date
      c. Tag number
      d. Plotting interval
      e. Time at start
      f. Time at latest value

**End of Control Strategy 7**

## Control Strategy 8
## Color Notation for Dynamic Objects on Control Graphic Display Screens

A. Reference Drawings:
   1. All P&IDs, all control strategies.

B. Description:
   1. All dynamic objects on control graphic display screens shall be provided with multiple-color display to identify status as tabulated below:

| Equipment | Status | Required color |
|---|---|---|
| Motor | Running | Red |
| Motor | Ready, Off | Green |
| Valve | Open position | Green |
| Valve | Closed position | Red |
| Gate | Open position | Green |
| Gate | Closed position | Red |
| All | Abnormal condition | Amber (Yellow) |

**End of Control Strategy 8**

**Control Strategy 9**
**Discrete Alarm System**

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. All discrete input alarms shall be provided as shown on P&IDs or listed in the instrument index (Section 40 06 70) whether or not specific control strategies are provided. Whenever a P&ID is not shown with any On/Off, Start/Stop, Open/Close or analog modulation control, no specific control strategy will be written even if a discrete alarm system is shown on the drawing. For this condition, control strategies shall be applicable. Discrete 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). A manual reset is required at the equipment control panel; Reset from SCADA is not acceptable.
   2. On a power failure, equipment shall return to the ready state when power is returned. Given the process condition, the lead piece of equipment shall start if called for. The lag and lag-lag, etc., starting sequence shall be staggered at 15-second intervals (adjustable) depending on the process. Operations shall designate this time during startup.

**End of Control Strategy 9**

## Control Strategy 10
## Discrete Status System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. All discrete input status shall be displayed on HMI screens as required by the reference drawings and specifications regardless whether or not specific control strategies are provided. Each discrete input shall be shown in its appropriate process screen and/or equipment status screen. Discrete 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).
   2. All equipment HOA selector switch Auto mode status contact is to be monitored by the PLC. When the HOA switch is not in the Auto mode the SCADA system shall display “Not in Auto” for that respective piece of equipment.

**End of Control Strategy 10**

## Control Strategy 11
## Variable Frequency Interface Signals

A. Description:
   1. Each variable frequency drive shall be provided with direct one-on-one hard-wired interfaces to the SCADA system. This interface shall provide control and monitoring of the adjustable frequency drive and the driven equipment including the motor.
      a. Each VFD control panel shall have the ability to START/STOP the motor from respective pushbuttons
      b. Ability to manually enter motor speed via a potentiometer, when in LOCAL mode, shall be included.
      c. Ability to view motor speed from digital panel meter on the control panel shall be provided.

B. SCADA Annunciation:
   1. The SCADA system shall display or annunciate (as indicated) the following conditions for each adjustable frequency drive and its driven equipment as well as the other conditions described previously in this Section:
      a. Off – Display
      b. Running – Display
      c. Speed Feedback – Display
      d. Failure – Annunciate
      e. Speed Setpoint - Display
      f. Remote - Display

**End of Control Strategy 11**

## Control Strategy 12
## Flocculators

A. Reference Drawing:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. The flocculator is a gentle mixer which increases the formation of floc resulting in increased clarity of the treated water. Coagulant is added to the water upstream of the flocculation process. The water treatment plant improvements are to convert two existing filter bays into flocculation basins. Each flocculator is to be driven by an electric motor connected to a VFD.
   2. Water flows into each flocculation basin through an electric-motor actuated valve, which shall be connected to SCADA to allow remote operation and control.
   3. Each actuated valve shall also be provided with a local control station to be mounted near ground level. This station shall allow operator opening and closing of the valve.

D. Control Descriptions:
   1. Local Manual Control:
      a. Each flocculator drive has a LOR (LOCAL-OFF-REMOTE) switch on the respective VFD. When the LOR switch is placed in the LOCAL mode the operator can start/stop the motor from VFD. Placing the LOR switch in the OFF position stops the motor.
   2. SCADA Manual Control:
      a. When the VFD's LOR switch is in the REMOTE position, the motor is controlled via the PLC/SCADA system. From the HMI, the operator is to choose the MANUAL option and start the motor. When in remote MANUAL mode, the operator may provide a speed setpoint.
   3. SCADA Auto Control:
      a. When the software control mode switch is in the AUTO position, the motor is to be started/stopped automatically by the PLC/SCADA system.

E. Interlocks and Permissives:
   1. Refer to the P&ID, elementary diagrams, and as per the pump manufacturer.

**End of Control Strategy 12**

END OF SECTION